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HENRY HOLT AND COMPANY

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THE SCIENTIFIC MONTHLY

MARCH, 1918

INSECTS AND THE NATIONAL HEALTH

By Professor CHARLES T. BRUES

BUSSEY INSTITUTION, HARVARD UNIVERSITY

AT the present moment, when America is embarking on one of the most stupendous undertakings ever attempted in her history, her resources and her obligations are weighed in the balance as never before. Industrial efficiency is fast responding to the demands made upon it and human efficiency should be increased in every way possible. The latter depends, of course, primarily on bodily food, and upon the security of the moral and physical health of the nation. These together involve a multitude of minor problems, and it is upon only one small aspect of public health that I have attempted to treat in the following pages. It seems peculiarly appropriate to call to public attention the pernicious activities of insects in relation to disease, since they present a problem which can be dealt with, at least to some extent, through individual effort and small community cooperation. The importance of insects as detrimental to public health is well known to professional zoologists, medical men and laymen alike, but is usually emphasized only under the stress of particular circumstances, such as the safety of soldiers in the present war, or of unusual outbreaks of diseases for which insects are directly responsible.

Insect-borne diseases present a constant menace to the world, and aside from the actual toll of lives which they exact, they impair its efficiency by enfeebling the health of its human population. Their direful influence is more pronounced in the tropics, whence it has been most commonly proclaimed, but our own country is by no means exempt, although its cooler climate causes it to be less severely affected.

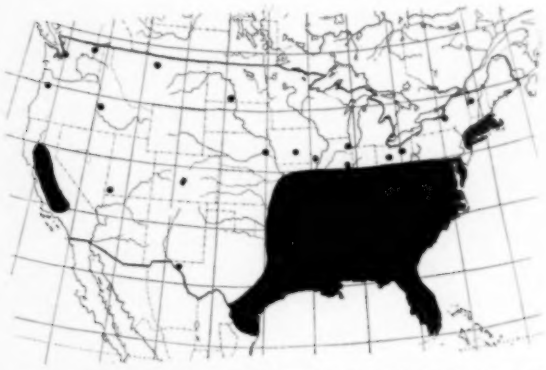
The following account is by no means complete. Its purpose is only to call attention to some of the more important disease-bearing insects in their relation to health in our own country.

Mosquito-borne Diseases.—No other insects can compete with the mosquitoes as persistent annoyers of man, and none, with the possible exception of the rat-flea, hold over him such power for evil. Practically no parts of the globe that can serve for human existence are free from mosquitoes and large areas from the tropics to the arctic are periodically invaded by them in varying abundance. Even where irrigation has made the "desert blossom like the rose" it has often also produced a crop of mosquitoes to annoy or even afflict with disease the inhabitants of the garden.

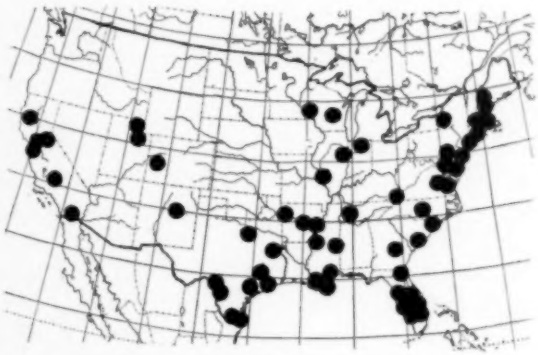
On account of their phlebotomic habits, and particularly their hominophilous tastes, mosquitoes have always been heartily detested, even by entomologists, and only their known association with human diseases has brought them to the serious attention of zoologists. With this incentive, however, a vast amount of work has been done by entomologists and medical men and an enormous mass of literature has been produced in less than two decades, bearing on every conceivable aspect of the subject. We now know that mosquitoes are responsible for many deaths, much human misery and great economic loss through their activity as disseminators of malarial fevers, yellow fever, dengue fever, filariasis, etc.

In all of this, several of the more important relations of mosquitoes to public health stand out very clearly. They are: (1) Some very important diseases of man are transmitted by certain specific mosquitoes, the latter being absolutely necessary for the continued existence of these diseases. (2) The disease-bearing mosquitoes are most widely distributed in the tropics, whence they extend into portions of the temperate zones. (3) The range of mosquito-borne diseases is not necessarily coextensive with the distribution of their insect carriers, but is dependent upon other factors as well. (4) Mosquito-borne disease may be combated either by the elimination of the mosquito responsible; by the protection of the population from its bites; by the careful screening of human patients to prevent them from infecting mosquitoes; or by a medical prophylaxis or immunization of the susceptible population. (5) Remedial measures are preferably applied against only the specific mosquitoes responsible, not against mosquitoes in general. The last is primarily a matter of economy, that the most vital needs of the community be first fulfilled; often more willingness on the part of the community is evinced to cooperate in fighting the most annoying or abundant species of mosquitoes rather than the ones most deleterious to the public health.

Of these methods, the first has proved the most generally



MAP 1. DISTRIBUTION OF MALARIA IN THE UNITED STATES (after Trask).



MAP 2. DISTRIBUTION OF MALARIAL MOSQUITOES IN THE UNITED STATES.

applicable, preferably combined with the second and third. The last has not proved generally suitable even with malaria, where quinine is a specific remedy, or with plague, where immunization is possible.

Malarial Fevers.—At the present time malaria in its several forms is the veritable scourge of the tropics. It also extends generally into the sub-tropics and warmer temperate regions and is prevalent over a considerable part of the southern United States. In these areas, as appears from investigations of the U. S. Public Health Service, its range is roughly coincident with the moist austral zones east of the 100th meridian as defined by Merriam. Aside from this main area, there is a small one in southern New England and another in central California; there are also a few isolated localities scattered through the country where malaria is thought to be endemic (see Map 1). At least three species of *Anopheles* are known to act as carriers of malaria in the United States and, from data given by Howard, Dyar and Knab (see Map 2), the distribu-

tion of these taken together corresponds closely with that of malaria, although slightly more extensive, especially along the Atlantic seaboard. As these malarious regions include a population of about 40,000,000 people, it will be seen that the importance of malaria from the standpoint of public health is very great indeed. It must be remembered, however, that the incidence of malaria varies widely, being greatest in the large southeastern area, and very much less in the more densely populated northern district. Thus in Mississippi about 80 cases of malaria per 1,000 of population were reported during the last year, or 158,000 for the entire state. Other southern states do not report the disease so thoroughly and it is difficult to estimate to what extent they are affected. It would seem, however, that one million cases each year would be a conservative estimate, especially as von Ezdorf found in a portion of one mill town in the endemic area that over 13 per cent., or one person in seven, harbored the malarial parasite in the blood, while 233 out of 500, or nearly 50 per cent., reported having had chills and fever during the summer preceding his examination. Although the death rate from malaria outside the tropics is not very great (9 per 1,000 calculated on the data for Mississippi cited above) it is by no means inconsiderable in the mass. On the other hand, the economic loss is enormous, due to inability to work during the acute attack of the fever and due to a loss of efficiency during prolonged periods following. That malaria responds quickly to anti-mosquito work and quininization is shown by the result following an application of these measures to the mill town mentioned. Referring to von Ezdorf's report, Trask says:

> Measures were inaugurated to get rid of mosquito-breeding places and the use of quinine was encouraged. A year later the town was again visited and the blood of 780 person examined. Of these only 35, or 4.5 per cent., showed infection. The health officer reported at this time that his visits among the mill employees for several months had averaged not over one a day, and that many of these were undoubtedly for old infections lasting over from previous years. The malaria rate had continuously decreased during the months when it was usually at its worst. The health officer of the town in his report for 1914 stated that while during the summer of 1913, prior to antimalarial work, the mills were constantly short of help on account of the large numbers of employees sick with malaria, during the summer of 1914 there had not been a day when the mills did not have sufficient help. The manager of one mill stated that the improvement in the regularity and efficiency of the employees had been such that the amount ($1,000) which the mill had contributed to the fund for anti-mosquito work was more than regained in one month's operation.

While these conditions are those of one of the most severely affected districts, they are nevertheless repeated very generally

throughout the entire area, more especially in the lowlands, for the hilly or mountainous and better-drained sections suffer less.

As mentioned above, several species of *Anopheles* mosquitoes are concerned in the transmission of malaria in the United States. Till very recently only one species, *Anopheles quadrimaculatus*, has been thought to be of much importance. Recent studies by Mitzmain and others show that this mosquito is the most important, as it may harbor the parasites of all three types of malaria, but *Anopheles punctipennis* (Fig. 1), a common, widespread species and *Anopheles crucians*, a species abundant along the eastern coast of the United States, may serve both as hosts for the tertian and estivo-autumnal or subtertian forms. The ease and frequency with which *A. punctipennis* may become infected seems to vary greatly under different conditions and its importance at least in northern districts is by no means proved.

FIG. 1. *Anopheles punctipennis*, female.

All three species readily enter houses and are persistent biters, although no more so than some other mosquitoes. Both *quadrimaculatus* and *punctipennis* breed in stagnant water, usually that of permanent nature containing algæ or other plant growth. They commonly occur together, with *punctipennis* usually more abundant. Larvæ of the latter species occur also rarely in temporary puddles and both are occasionally to be found in the growth along the sides of slowly flowing streams. The breeding grounds of *A. crucians* are mainly restricted to regions adjoining the salt and brackish marshes along the coast, although the larvæ are most abundant in fresh water. The two *Anopheles* occurring on the Pacific coast region, *A. pseudo-punctipennis* and *A. occidentalis*, have habits similar to those of *quadrimaculatus*, although the second species breeds in brackish waters also. As is the general habit among adults of *Anopheles*, these mosquitoes feed mainly at twilight and malaria is acquired only by persons who expose

themselves to their bites after nightfall. Occasionally they bite during the daytime, but as malaria appears never to follow such bites it seems probable that only newly emerged females and consequently non-infected ones bite at this time, as is the case with the yellow-fever mosquito.

Like other insect-borne diseases, malaria shows in its sea-

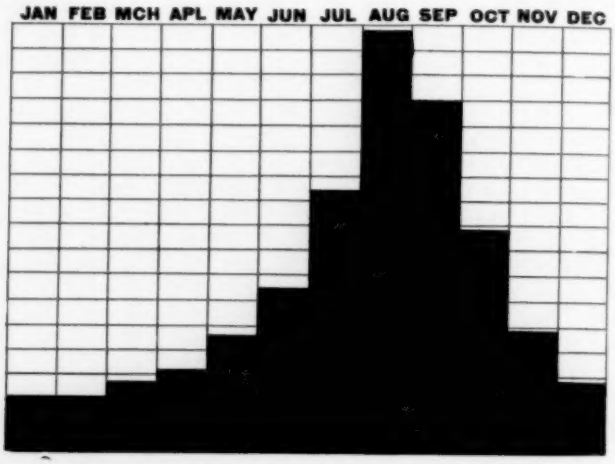


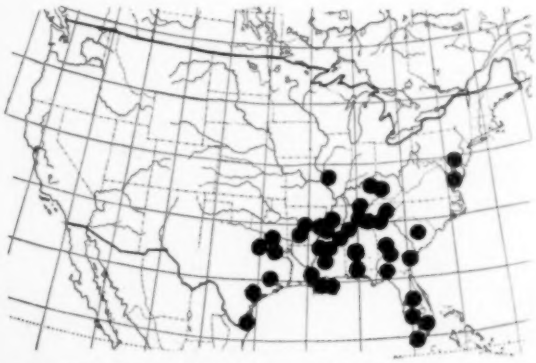
FIG. 2. SEASONAL PREVALENCE OF MALARIA IN THE UNITED STATES.

sonal prevalence a close relation to the seasons (see Fig. 2), undergoing a period of quiescence during the winter and attaining a sudden maximum in late summer, after which it rapidly declines. This is in response to the increasing abundance of *Anopheles* during the summer, coupled with a relatively high temperature, favorable for activity on the part of the mosquito and for the development of the malarial parasites in its body. It has recently been clearly shown by Mitzmain that under the conditions of temperature prevailing in the United States the malarial parasites do not persist through the winter in hibernating mosquitoes, but winter over in the human host from whence the *Anopheles* secure them the following season.

As already pointed out, the reduction of malaria in communities is permanently accomplished most readily by the application of anti-mosquito measures, aimed mainly at the breeding-places of *Anopheles* mosquitoes. Such work is being extensively carried on by the U. S. Public Health Service, by other federal bureaus, by many state boards and commissions, and by certain private or semi-private institutions in widely scattered parts of the country. Through their individual and collective efforts an enormous amount has been accomplished, although painfully little in comparison with what could well be spent

upon the problem, which is without question one of the great public-health problems in the United States at the present time.

Yellow fever no longer causes serious concern to residents of any part of the United States, or, for that matter, to those of most parts of the American tropics. Most of us can recall very clearly in the not far distant past, however, the terror and demoralization which accompanied its periodical appearance in our southern ports. The yellow-fever mosquito is still abundant and widely distributed throughout the southeastern states (see

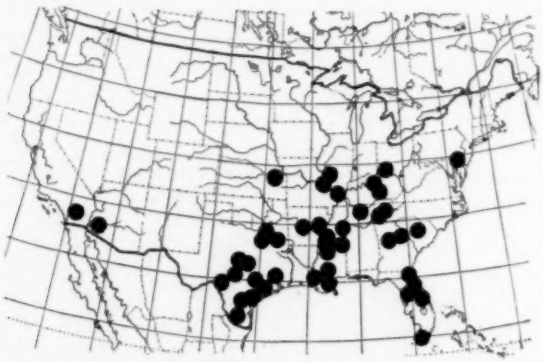


MAP 3. DISTRIBUTION OF THE YELLOW-FEVER MOSQUITO IN THE UNITED STATES.

Map 3) and sometimes becomes temporarily established further north during the summer. There is no yellow fever, except an occasional stray case from the tropics, which does not get beyond the keen eyes of the Public Health Service, and consequently our population of yellow-fever mosquitoes remain free from the dread disease. In this case several factors have combined to make possible the elimination of the disease without more than temporary and local eradication of the mosquito. In our southern states the disease does not easily survive the winter and chronic human carriers do not exist, so that past outbreaks have been due to fresh introductions and have been terminated by cold weather. During the last epidemic that occurred in New Orleans, in 1905, vigorous anti-mosquito measures were necessary, but, due to the greater severity of the disease, the consequently greater ease with which it is recognized, the limited area to be dealt with, and the absence of chronic human carriers, the eradication of yellow fever without permanent mosquito repression has been easy in comparison with the control of malaria. Even in parts of the tropics where it persists throughout the year, it is being rapidly and permanently eliminated. Indeed it bids fair to be the first disease actually to become extinct as a direct result of human discov-

ery and applied science. What a refreshing contrast to the fate of the American pigeon and the forlorn remnants of the American bison!

Another tropicopolitan, semi-domesticated mosquito extends quite widely into the warmer parts of the United States (Map



MAP 4. DISTRIBUTION OF *Culex quinquefasciatus* IN THE UNITED STATES.

4). This is *Culex fatigans*, now known as *Culex quinquefasciatus* (Fig. 3), mainly, if not entirely, responsible for the transmission of a parasite of the blood-stream and lymphatics caus-

FIG. 3. *Culex quinquefasciatus*, female.

ing filariasis or elephantiasis. In this connection it is of small importance to us, as this disease is very uncommon in the United States, but as a carrier of dengue fever or "break-bone fever" it is of considerable importance. Dengue is a mild

(*i. e.*, non-fatal) disease which causes great distress and temporary disability. It is therefore a factor contributing to lack of efficiency and goes hand in hand with malaria in this respect. Like malaria, dengue is tropicopolitan in range, and extends only into the warmer parts of the south. Here it sometimes appears in extensive epidemics, but in a much more erratic way than malaria, which has the well-deserved reputation of appearing year in and year out in the same districts. This difference is probably due to the absence of chronic human carriers and the fact that *Culex quinquefasciatus* does not breed in permanent water, but in an almost truly domesticated species which breeds in temporary water near human habitations, and under the climatic and other conditions of our country does not find anything like uniform opportunities for breeding from one season to another. In consequence of their separate breeding-grounds, measures designed to control malarial mosquitoes have no effect or practically none upon the dengue mosquito. It must be dealt with mainly by education leading to individual effort and cooperation in communities. Aside from its pathogenic possibilities, this species is a rather persistent biter, which is another argument for its control.

Less directly detrimental to public health are other mosquitoes not associated with any human disease, but making life miserable at some season of the year for human beings in practically all parts of the world. Although the United States supports an extensive mosquito fauna, a very few species aside from those already mentioned make up the bulk of those annoying man. Two particularly are widespread, abundant and on account of their strikingly different habits, perhaps worthy of mention in this connection. The first of these is the house mosquito, *Culex pipiens*, a palearctic species, now common throughout the eastern states, that breeds in rain-barrels, cesspools, sewer-catch-basins, puddles or practically anywhere, no matter how foul the water. The other, *Aëdes sollicitans*, the salt-marsh or "Jersey" mosquito, breeds only along the coast in salt-marshes. Broods of this mosquito follow the lunar calendar, developing after the high tides flood the meadows and fill the pools in which the larvæ live. The eggs of this form are laid on the mud and hatch quickly when submerged in water. It is generally believed that all the eggs laid by this mosquito must pass the winter before hatching and that the successive broods are only installments of eggs induced suddenly to hatch in turn by successive wettings. This is a true migratory mosquito, which invades the country for many miles adjacent to

the salt-marshes. Such incursions follow the appearance of each brood.

Much attention has been given to the control of this mosquito in New Jersey and the territory surrounding Long Island Sound, and its numbers have been marvelously lessened through the drainage of marshes by ditching. In the case of this species reforms have been easier than with the malarial mosquitoes, as an expectation of relief from the great personal discomfort of myriad mosquito-bites exerts a stronger appeal to the average person than the much more important health problem of malaria. In the public mind, the latter is unfortunately not usually regarded as so immediately personal, as the fever and the bite are not coincident.

Black-flies.—At some time during the insect season, usually in the spring, many districts are visited by swarms of small hump-backed flies which viciously bite man and animals alike. On account of their dark color these have been called black-flies. They pass their developmental stages almost entirely in swiftly moving brooks and streams, where the larvæ and pupæ are attached to stones and other objects in the water. Wherever there are suitable streams in which they can breed, these pests appear abundantly, and may be occasionally present far from streams, where they would not be expected. They are not known to be concerned in the transmission of any disease.

Biting-midges, Sand-flies, Etc.—Minute flies, somewhat like mosquitoes, which are vicious blood-suckers, often appear in great abundance, particularly in the cooler parts of the United States. These insects belong to several genera, developing from aquatic larvæ inhabiting fresh water and also brackish water along the sea-coast. They are generally crepuscular, biting most abundantly at dusk, and are very persistent at that time, causing a stinging sensation out of all proportion to their almost microscopic size. None of our species are known to be disease-carriers.

Housefly Diseases.—Of these it may be urged that, strictly speaking, there are none, at least in the sense of mosquito-borne diseases. The housefly is not known to be wholly responsible for the transmission of any disease and its relative importance in disseminating several infections of man is still a moot question. By some it is strongly urged as the main means of transmission for several enteric diseases in certain communities; by others it is cast aside without reasonable consideration as a sort of entomologist's nightmare. I can not believe that either course is justified; each seems to be based on prejudice due to

lack of knowledge, either respecting the fly or relating to other channels of infection.

The housefly (Fig. 4) is more truly domesticated than any other insect; it lives and flourishes wherever man establishes himself, but does not thrive elsewhere. It has evidently been

FIG. 4. HOUSE-FLY FEEDING ON A LUMP OF SUGAR.

associated with him from the remotest antiquity, but has by no means failed to adapt itself to changed conditions. It still develops in his feces or those of his domestic animals and still invades his habitations to partake of his food. In short, it is practically ever-present, for its preferred larval food, horse manure, is usually to be found, and, if not, substitutes are available in greater or less abundance.

The chain of events through which the housefly may infect food with bacteria or other organisms derived from excremental materials is obvious and has been so repeatedly described that it is unnecessary to outline it here. The frequency with which this actually happens is of course the vital point, and it is upon this that it is very difficult to obtain concise data.

It has been shown rather conclusively that adult flies do not retain in the alimentary tract bacteria which they may have ingested as larvæ that have developed and fed in material containing, for example, the bacillus of typhoid fever. On the other hand, adult flies readily obtain this bacillus from contaminated substances and may retain and later deposit it in a living condition on food designed for immediate human consumption. There can be no question but that this occurs commonly under many circumstances, particularly in communities where there is no adequate system of sewage disposal. That

these bacteria should be more attenuated than those occurring in drinking water does not seem probable. Many facts show that flies are a very important factor in the dissemination of typhoid fever. The greater frequency with which persons on country vacations contract the disease is very striking, although this may, of course, be attributed to bad water supply. Other opportunities for infection, aside from the fly, are, however, no greater there than in the city. In other parts of the world where the water supply is reasonably good, *e. g.*, certain South American cities, typhoid flourishes to an alarming extent, due undoubtedly to excessive soil pollution, where flies can almost instantly transfer material from typhoid carriers to food, while the latter is abundantly exposed on the streets for sale to be eaten on the spot. In our own country the seasonal incidence of typhoid fever corresponds to some extent with fly prevalence, and still more significant is its greater summer prevalence in regions where systems for sewage disposal are not generally installed. This disparity is shown on the accompanying chart (Fig. 5), which gives data for two of our eastern states, New

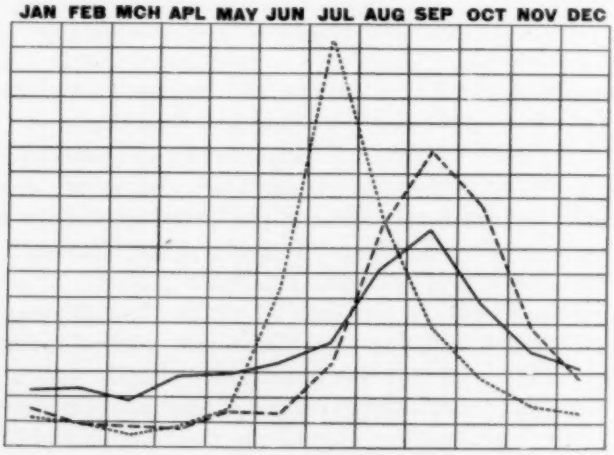


FIG. 5. SEASONAL PREVALENCE OF TYPHOID FEVER IN SEVERAL STATES; solid line, New York; dotted line, Alabama; dashed line, Washington.

York and Alabama, and one western state, Washington. The greater uniformity throughout the year in New York, where the opportunities for fly-borne infection are curtailed, is very marked. Another way in which the housefly can aid in the spread of typhoid is through infecting milk on dairy farms where carriers are present and offer the flies a chance to become infected.

Flies are also responsible, and to a much greater extent,

for the prevalence of infantile diarrhea or summer complaint, and here their relation is very easily seen.

Other activities of houseflies detrimental to public health are of far less importance, but by no means negligible. They can carry the eggs of parasitic worms as well as many bacteria and other microorganisms present in the several types of unsavory food upon which they feed indiscriminately.

Recently much progress has been made in methods of abating the housefly nuisance. It has been found by workers in the Federal Department of Agriculture that certain substances, notably borax, hellebore, and a fertilizer consisting of calcium cyanamid, acid phosphate and kainit, are highly destructive to fly-larvæ in horse manure (whence the great majority of our house-flies come) and that these substances do not ruin the manure for agricultural purposes. Practical traps whereby fly-larvæ in stored manure may be caught and destroyed before transformation have also been devised. Richardson has shown that house-fly larvæ can develop only in alkaline material, and some substances may thus be acidified to eliminate them as larval food.

The people of the United States spend great sums of money for fly-screens, fly-paper, fly-swatters and fly-traps and suffer

FIG. 6. STABLE-FLY (*Stomoxys calcitrans*).

much sickness and death as a result of the ubiquitous housefly. As yet no great reduction of houseflies has been accomplished, but the public regards them less and less as harmless creatures, and should soon be in the proper mental state to launch a decisive campaign against them.

The Stable-fly.—Cattle, horses and other domestic animals,

and more rarely man himself, are troubled in nearly all parts of the world by a small blood-sucking fly resembling the house-fly in size and general color (Fig. 6). On account of its great abundance about horses and cattle it has been termed the stable-fly, although its larvæ breed mainly in fermenting vegetable material rather than in manure. The adult flies readily bite human beings, particularly in damp weather, and this habit has given rise to the popular idea that house-flies bite before a shower. The stable-fly is most important as a pest of animals, as it has not been definitely proved to be more than an accidental carrier of any disease affecting man. It was at one time thought to be a carrier of poliomyelitis (infantile paralysis), but it now seems probable that such it not the case.

Typhus Fever.—Although this louse-borne disease is of prime military importance in some parts of the world, it is practically non-existent among the civil or army population of the United States. That it should ever be revived seems unbelievable, for it has passed from the proportions of gigantic epidemics in the middle ages to insignificant local outbreaks, corresponding to the continuous improvement of sanitary conditions in our own and other countries. The relaxation of such checks in war-ridden countries has always spelled a temporary increase in typhus. We have every reason to foresee, however, during the present war less typhus than would have been thought possible were the manner of its transmission by lice not known.

Rocky Mountain Spotted Fever.—This is the only definitely characterized tick-borne human disease that occurs within the confines of the United States, although ticks are responsible for the transmission of several other important infections of man in various parts of the world. Rocky Mountain spotted fever is restricted to the far western and northwestern states, whence 290 cases were reported during the year 1916. Over half of these occurred in Idaho, although the disease extends into the neighboring states of Montana, Wyoming, Colorado, Utah, Nevada, California, Oregon and Washington, as well as northward into Canada. As shown by the indicated fatality rate, the disease is most virulent in western Montana and northern Idaho, where the mortality is said to reach 70 or 80 per cent. A single species of tick, *Dermacentor venustus* (Fig. 7), common in these regions is known to act as the vector. The *Dermacentor* ticks occur abundantly on various small wild mammals in the younger stages and as adults on domesticated animals, such as cattle, and from these become transferred to man. It has been experimentally shown that certain rodents are susceptible to the disease, and that a tick thus infected in

the nymphal stage can retain the disease organism till it becomes adult. It may then reach its human host through the medium of domesticated animals such as cattle. It appears that this is the ordinary way in which human cases have their origin, *i. e.*, through the bites of adult ticks, although the newly hatched "seed ticks" derived from eggs laid by infected mother ticks are known to contain the organism also.

Although Rocky Mountain fever is of minor importance at present, it is feared that it may increase its range at any time, since other ticks of wider distribution are apparently capable

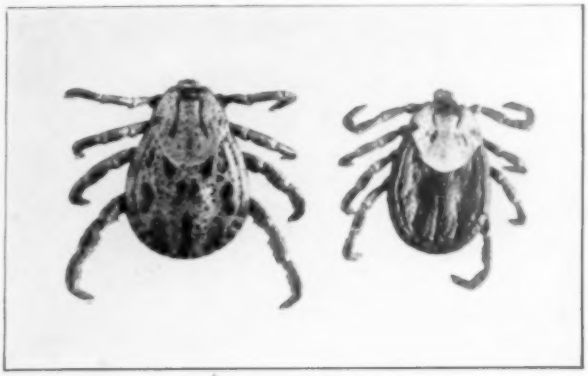


FIG. 7. ROCKY MOUNTAIN SPOTTED-FEVER TICK, male at left. Unengaged female at right.

of acting as carriers. Whether this may happen is by no means certain, however, and the vigorous measures already undertaken to reduce the abundance of ticks on domesticated animals will undoubtedly bear fruit in the gradual reduction of this locally much-dreaded disease.

Bubonic Plague.—From 300,000 to 400,000 cases of this disease are reported from India every year, over half of which terminate fatally. In past centuries it periodically visited many parts of the world as epidemics of even greater proportions, causing it to rank as one of the worst scourges of mankind. As is now well known, plague is a disease of rats which becomes transferred to man almost exclusively through the agency of fleas. At the present time it is most widespread and abundant in tropical countries, although by no means confined to them, and is excluded from our own country only by dint of repressive measures administered with the greatest thoroughness. Within the past few years it has appeared only sparingly in the United States, but at several times has given rise to a temporary apprehension lest it pass beyond control. That

FIG. 8. TROPICAL RAT-FLEA (*Xenopsyllachcopis*).

it has not done so shows that the probability of future danger is remote.

Nevertheless there are other good reasons why we should spare no efforts in reducing the number of rats. They are said by Nelson to destroy annually $200,000,000 worth of our foodstuffs and other property; they constitute a fire-menace, and, besides, they can hardly be considered as deserving our hospitality from an esthetic standpoint. In short, war against rats is important for many reasons, one of which is the security against plague which it entails, and gradual repression through individual effort is much easier than intensive campaigns necessitated by the advent of plague in a community.

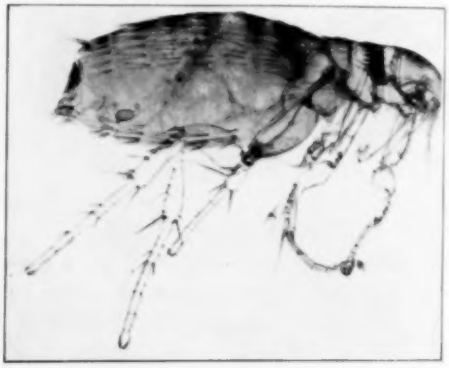


FIG. 9. RAT-FLEA OF TEMPERATE REGIONS (*Ceratophyllac fasciatus*).

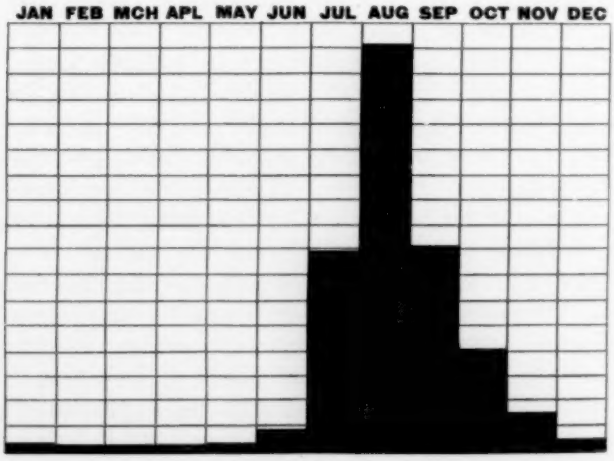


FIG. 10. SEASONAL INCIDENCE OF INFANTILE PARALYSIS IN THE UNITED STATES DURING 1916.

The relation of the flea to the transmission of plague is due to the fact that rats are regularly infested by fleas that may become infected with the bacillus of plague, if it be present in the blood of the host upon which they are feeding. These bacilli remain in a viable condition for some time in the gut of the flea and may be transferred to a human subject bitten by an infected flea. Thus, when a rat dies of plague, its fleas leave it to search for a new host; if they attach themselves to a rat, that animal is liable to infection, or if they feed upon a human being, as they frequently do, the disease may become transferred to man. Two species of fleas are commonly concerned in the transfer, one in tropical and subtropical regions and another in temperate regions. The tropical rat-flea, *Xenopsylla cheopis* (Fig. 8) is thus of greatest importance in the warm countries where it is most abundant, and the other, *Ceratophyllus fasciatus* (Fig. 9), in cooler countries. Both occur in the United States, neither specifically associated with plague except as previously outlined; other fleas may act as carriers equally well, but are not so abundant on rats and do not bite persons so frequently.

Infantile Paralysis.—Perhaps a few words in regard to this baffling disease may not be amiss. There are strong reasons for believing that it is carried by insects. Its summer prevalence (Fig. 10) is well known and its general distribution and occurrence are similar to those of insect-borne diseases. That it may be proved to be spread by the rat-flea is not improbable, and if so, would be another strong argument for the reduction of our rat population.

ZOOLOGY AND THE WAR

By Professor MAYNARD M. METCALF

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THE request to write upon zoology and the war suggests two lines of thought—first the contribution zoology is making, and may make, to effective conduct of war activities of various sorts, and second the effects upon zoological science and practise likely to follow from the war. Both are worth considering.

Speaking broadly, no other science is doing more, perhaps none as much as zoology, or rather biology, to promote effective and successful prosecution of the war. This seems a strong statement, as one thinks of our dependence upon chemistry for explosives and a thousand other products, upon mechanics for ordnance and all sorts of war engines and upon engineering for the great activities of military and naval construction. Of course all the sciences are so interdependent that no comparisons can really be drawn. The statement is of value chiefly to challenge attention and persuade the reader to examine the relation of zoology—purely scientific zoology—to the problems of the war.

Man is an animal and all our knowledge of him and his activities is biological and all our methods of dealing with him and his life must be founded upon biological science. A mere roster of the biological sciences is sufficient to show our dependence. Some of these are: Morphology, including anatomy and embryology; physiology, both normal and pathological; ecology, including parasitology with bacteriology as its major subdivision; genetics; psychology; surgery and scientific medicine are but an application of anatomy, physiology and parasitology; and perhaps as vital as any in its effects upon all human life has been the knowledge of the fact of evolution.

It is often said this war is a scientific war and it is true both in its destructive aspects and in its safeguarding and protecting features. It is equally true that when all is said as to guns and explosives and poisonous gases, the last word lies with the man power of the belligerents. And it is here that zoology's great service is rendered. It is purely biological studies that have made possible the assembling of great numbers of men without disease slaying far more than fall before

the guns of the enemy. The surgery which restores ninety per cent. of the wounded would be impossible without the knowledge reached by decades of parasitological research. Our knowledge of sanitation and the prevention of infectious disease has doubtless saved many more combatants and non-combatants than have been slain in all the battles. It isn't only Serbia which has been saved from typhus. Without our knowledge of the method of transmission of this disease, and the preventive measures thus made possible, all the belligerent nations would have been worse than decimated by this scourge. Typhoid fever, cholera, bubonic plague, smallpox, would each have taken similar toll. For every dozen lives lost from battle, hundreds would have been destroyed by infectious diseases which we are now able to hold in check.

Of course there are many lesser contributions to war effectiveness through animal husbandry and our knowledge of the sea and its life—all dependent upon zoological research.

But more important than any or all of these specific benefits from biological research has been the introduction of the era of scientific thinking, which since Darwin's time has been replacing superstition and ignorance. Step by step the physical sciences fought their way to recognition, but the dawn of the new age really came only when the phenomena of human life were recognized as biological and the puerile distinction between science and the humanities was destroyed. From this time the approach to human problems could be truly scientific without reservation, and the ideals themselves could be scientific. Tested truth, that is science, became the means and the goal.

It is this change in our whole habit of thought that has brought the advance in all lines of science, giving us our discoveries and inventions, creating whole new departments of science before undreamed. We must not overestimate biology's share in this emancipation of the human mind. Its contribution was later and more conspicuous, but no more real, than those of other sciences. The promulgation of the idea of evolution, coming last, as it did, and attacking superstition in its very citadel in the life of man, was recognized by opponents of the scientific spirit as bringing the last ditch fight. Without this fight and its victory for the forces of progress, the scientific development of the last fifty years could never have occurred. Biology therefore has had its full share in bringing the present day of science. It is this great spiritual contribution to human life that most merits recognition, for from this have flowed all the beneficent activities in every field of science.

Recognizing then the broad service of zoology with the other sciences in helping to the emancipation of man's mind, and remembering as well the special services in medicine, surgery and sanitation and in the production of food and clothing, the zoologist to-day may be somewhat consoled for the fact that in general it is more difficult for him than it is for the chemist or physicist to find ways to use effectively his special training in immediate war service. The transition from pure zoology to special war service is more difficult than that from chemistry or physics.

And it is just here there lies a very real danger to zoological science and to society. The earnest desire to serve in the great emergency, to take an immediately effective share in the strenuous tasks of the war, seems altogether likely to result in overemphasis upon the idea of practical applications in science, to the detriment of the pure science that is the fountainhead. The danger is real.

In some ways zoology is more exposed to injury than some of the other sciences. The pure zoologist must be a good bit of an idealist. Choosing zoology one chooses poverty. In medicine there is fair monetary return. The chemist or physicist knows that in this day of great industrial development and of great construction he can always, if need be, find employment for his trained abilities in ways to bring him money. But in turning to zoology a young man takes Franciscan vows of poverty of purse and enters upon the simple life. This is a sufficient handicap for our science. Add to this the somewhat general impression that in this war the zoologist has often found difficulty in rendering service in the line of his special training and there is real danger of further disadvantage to zoology and of a considerable reduction in the number of college and university students choosing zoological science as their life work. Philistinism, overestimate of the so-called practical, may be as harmful in science as in esthetics.

What is the most helpful attitude in science? What spirit is most productive in research? Is it the desire to make discovery for the sake of financial profit to the student? Is it personal ambition for honorable and dignified position among men of science? Is it the purpose to bend every effort immediately toward direct promotion of human welfare? No, it is something far different from any of these. The man works best who is in the thing for the fun of the game, who follows science because of interest in science itself and not so much in the so-called practical benefits reached through scientific re-

search. There is no field in which singleness of purpose counts for more than it does in science.

There is the greatest danger that ulterior motive will warp the judgment of the student, and if he attempts too much to guide his studies toward practical utility he is less likely to reach major results than if he humbly allows his science to lead him where it will. All science is one great system of truth, interlocked in countless ways, and at almost every step in its pursuit there open to the student great vistas of unexplored territory—heights of vantage from which, when attained, he may view certain areas as a whole and grasp their true relations. The big things in science come through those who are seeking these visions, rather than through those who are searching at each step to gather some nugget of commercial value. In science, as in all life, it is idealism that leads to largest result, and the progress of the world in so-called practical lines is dependent upon the idealist more than upon the student with more immediate purpose. The future of science and of society rests with the seekers for the vision, those who search for understanding of truth for the joy of knowing the truth, rather than the profit such knowledge may bring.

Periods of great emphasis upon the *utilization* of science, such as is this time of war, bring danger of false estimates. There is real risk that the immediate will loom disproportionately large and that the spirit of searching for truth for the very joy of its attainment may in a measure be lost, and it is this spirit that is needed to "guide us into all truth."

One very real service the devotee of pure science can render, therefore, is to keep burning, and burning brightly, the fire upon his altar. Like his brother in other fields, the zoologist should recognize that he worships at no unworthy shrine, and he may well allow others to see something of his loyalty and of his pride in his service. May the light from his altar fire guide many another earnest student to the same shrine, though in coming he passes broader and easier paths.

There is much to-day to discourage. The moving picture, the cheap magazine, the daily newspaper, are real indications of low standards of taste in the drama, in literature and in all life. It seems the day of the low-brow. The man of science who seeks truth in all her beauty can do his full share in resisting this resurgence of philistinism and tawdriness, and he can do it by insistence for himself upon the worthier quest. Can he render in the end any greater national service?

PAPERS PRESENTED BEFORE THE SECTION OF SOCIAL AND ECONOMIC SCIENCE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A COMPREHENSIVE IMMIGRATION POLICY AND PROGRAM[1]

By SIDNEY L. GULICK, D.D.

SECRETARY OF THE COMMISSION ON RELATIONS WITH THE ORIENT OF THE FEDERAL COUNCIL OF THE CHURCHES OF CHRIST IN AMERICA

THE need of adequate and wise immigration and Americanization legislation is imperative. Now, while war suspends the tide of newcomers to our shores, is the time for enacting the new laws to regulate the coming of fresh aliens.

No one can foretell how large or small will be the immigration from the war-ravaged countries of Europe when the war ceases. Wages in America will be high and the demand for cheap labor will be urgent. Immigration companies and steamship lines will seek for fresh sources of cheap labor to bring to America.

The large influx of foreigners in recent years has produced a serious situation. Our laws have not adequately grappled with the many kinds of problems which have arisen. Present laws afford no method of control either of the numbers or of the race types that may be admitted. We have reason to expect a large immigration of peoples that will prove extremely difficult of Americanization.

Vast masses of aliens in our midst are not Americanized and we have no effective provision for their Americanization. We give them citizenship with very inadequate preparation for it. The procedure in naturalization is needlessly hampered by red tape. We allow serious congestion of race groups. Free immigration from Europe constantly threatens standards of living of American workmen. Differential treatment of, and legislation against, Asiatics produces international irritation. Lack of laws makes it impossible for the United States to keep its treaty obligations for the adequate protection of aliens.

These varied dangers threaten the success of our democracy.

[1] Pittsburgh meeting, December, 1917, arranged by the Secretary of the Section, Seymour C. Loomis.

We now need a comprehensive and constructive policy for the regulation of all immigration, and the Americanization of all whom we admit, a policy that is based on sound economic, eugenic, political and ethical principles, and a program worked out in detail for incorporating that policy into practise.

If we are to attain the best results we should have a series of bills that deal with all phases of the immigrant question, in a systematic, comprehensive and well-coordinated plan in place of the patchwork, incomplete and disconnected legislation that now exists. Our new comprehensive policy, moreover, must take into consideration not merely the relations of America with Europe, Africa and West Asia, but also with China, Japan and India. The world has become so small and travel has become so easy that economic pressure and opportunity are now bringing all the races into inevitable contact and increasing intermixture. To avoid the disastrous consequences of such contacts and intermixtures, and to enable the United States not only to provide for her own prosperity, but also to make to the whole world her best contribution for human betterment, we need policies that are based upon justice and goodwill, no less than upon economic and eugenic considerations.

The following proposals are offered as a contribution to the discussion of these important matters:

Recent immigration has been enormous (10,122,862 for the ten years ending June, 1914) and will in all probability sooner or later become so again. For the poverty of Europe and the frightful taxes that will be inevitable, together with the horror of militarism which has deluged the nations with blood, sown the fields with human bones, and overwhelmed all working classes, will cause millions to flee to a land free from militarism and relatively prosperous.

Although America has vast resources, two thirds of our toilers have been in serious poverty, receiving less than $15 per week when they work. Even at that rate, however, until after the outbreak of the war, they have not been sure of steady employment. The Federal Commission on Industrial Relations has disclosed how serious have been the problems of unemployment and industrial unrest. War prosperity and cessation of immigration have relieved the economic strain for the present. What, however, will be the situation when vast immigration begins again?

America's political institutions and social organization are based on democracy. There is developing among us, however, a large adult male alien population still owing allegiance to other governments. The last census (1910) shows that out of

5,942,000 foreign-born males in America twenty-one years of age and over, 3,221,000 were still aliens. While 770,000 born in Great Britain had become citizens of the United States, 449,000 were still British; in the case of Germany 889,000 had become naturalized, while 389,000 were still Germans. Those, however, who come from South Europe seem less ready to become Americans. Austria, for instance, gave us 149,000 naturalized citizens to 460,000 aliens; Hungary 36,000 citizens to 219,000 aliens, and Russia 192,000 citizens to 545,000 aliens; while Italy gave us only 126,000 citizens to 586,000 aliens.

How many of these aliens had been here less than five years and therefore were still ineligible for citizenship the table did not show. But, however that may be, it seems wholly undesirable that the proportion of aliens to naturalized citizens from any particular land should be so large as these figures show. Should not the rate of permissible immigration be such as to keep the aliens from any land always in a substantial minority of those from that land who have become American citizens?

These facts and considerations suggest the importance, on the one hand, of checking this inflow of vast numbers who maintain allegiance to foreign governments, and also, on the other hand, of promoting such education of aliens permanently residing in America as shall help them rapidly to acquire our ideas and ideals, and transform them speedily into true American citizens.

The need of regulating immigration from Europe and West Asia is so well recognized that nothing further will be said upon it in this brief discussion. It is important, however, that Americans should realize that the present laws dealing with Japanese, Chinese and Hindus are quite obsolete. They are not only obsolete; they are positively dangerous.

New Japan has already acquired the mechanical instruments, the political, economic and industrial methods, and the science, education, ideas and ideals of Occidental civilization. New China is rapidly following in the footsteps of Japan. Both are increasingly self-conscious and insistent on courteous treatment and observance of treaties. They are asking, with growing earnestness, for recognition on a basis of equality with nations of the West.

The great world-problem of the twentieth century is undoubtedly the problem of the contact of the East and the West. Whether it shall bring us weal or woe depends largely on the United States. Shall our Oriental policy be based on race pride, disdain and selfishness? Shall it be entirely devoid of sympathy? And shall we rely on brute force for carrying it

through? Or shall we give justice, courtesy and a square deal, refusing to be stampeded by ignorance, ill-founded suspicion and falsehood? Shall we "prepare" to maintain by our military might a policy of arrogant disregard of their needs and feelings, or shall we remove dangers of conflict by a policy of friendly consideration and genuine helpfulness?

The New Orient renders obsolete and dangerous our nineteenth-century Asiatic policy. Let us now promptly adopt a new policy; one that will provide, on the one hand, for the just demands of the Pacific Coast States to be protected from a swamping Asiatic immigration; and yet that also provides on the other hand for full courtesy of treatment and for complete freedom from race discrimination, which is inevitably regarded as humiliating. The new policy should provide for observance of the spirit no less than of the wording of our treaties, and be thus in harmony with the principles of good neighborliness.

All this means that we need comprehensive immigration legislation dealing with the entire question in such a way as to conserve American institutions, protect American labor from dangerous economic competition, and promote intelligent and enduring friendliness between America and all the nations, East and West, because free from differential race treatment.

The legislation needed should deal with:

1. The regulation of immigration.
2. The registration of aliens.
3. The distribution of immigrants.
4. The education of aliens for American life.
5. The protection of aliens by the federal government.
6. The naturalization of aliens.

Legislation dealing with these matters should be controlled by the following principles:

1. The United States should so regulate, and, where necessary, restrict immigration as to provide that only so many immigrants of each race or people may be admitted as can be wholesomely Americanized.

2. The number of those individuals of each race or people already in the United States who have become Americanized affords the best basis of the measure for the further immigration of that people.

3. American standards of living should be protected from the dangerous economic competition of immigrants, whether from Europe or from Asia.

4. Such provisions for the care of aliens residing among us should be made as will promote their rapid and genuine Americanization and thus maintain intact our democratic institutions and national unity.

5. The federal government should be empowered by Congress to protect the lives and property of aliens.

6. All legislation dealing with immigration and with resident aliens should be based on justice and goodwill as well as on economic and political considerations.

IMPORTANT SPECIFICATIONS

1. Regulation of the Rate of Immigration.
   The maximum permissible annual immigration from any people should be a definite per cent. (say five) of those from that people who have already become naturalized citizens, together with all American-born children of immigrants of that people.
2. A Federal Bureau for the Registration of Aliens.
   A Federal Bureau for the Registration of Aliens should be established and all resident aliens should be required to register and to keep registered until they have become American citizens. A registration fee (ten or perhaps five dollars a year) might well be required of all male aliens eighteen years of age or over.
3. The Federal Distribution Bureau.
   The Federal Bureau for the Distribution of Immigrants should be developed and provided with increased funds for larger and more effective methods.
4. A Federal Bureau for the Education of Aliens.
   A Federal Bureau for the Education of Aliens for American Citizenship should be established. While this bureau should not set up its own schools, its duty should be to promote the establishment by local bodies of suitable schools in needful localities and all registered aliens should be given education for citizenship free of cost. The bureau should be provided with funds for subsidies to be granted to schools upon the fulfilment of conditions prescribed by the bureau. The registration fee of aliens might well be reduced by one dollar ($1.00) for every examination passed.
5. Congressional Legislation for the Adequate Protection of Aliens.
   Congress should at once enact a law enabling the federal government to exercise immediate jurisdiction in any case involving the protection of and justice to aliens. The treaties place this responsibility on the federal government, but no laws as yet give it this power. The bill drafted by Hon. Wm. H. Taft and endorsed by the American Bar Association, or some similar bill, should be passed.
6. Amendment of Naturalization Laws.
   The standards of naturalization should be raised. Only those applicants for naturalization should be regarded as qualified who have passed all the examinations of the schools for citizenship and who have maintained their registration without break from the time of their admittance to America. Under the foregoing provisions and rigid limitations as to numbers and qualifications, naturalization should be given to all who qualify regardless of race.

A FEW ADDITIONAL DETAILS

(*a*) No change should be made in the schedule for maximum immigration between the census periods. With each new census a new schedule should be prepared, but it should not go into operation automatically. Congress should reconsider the whole matter once in ten years upon receiving the figures based upon the new census, and decide either to adopt the new schedule or some new percentage rate, or possibly to continue the

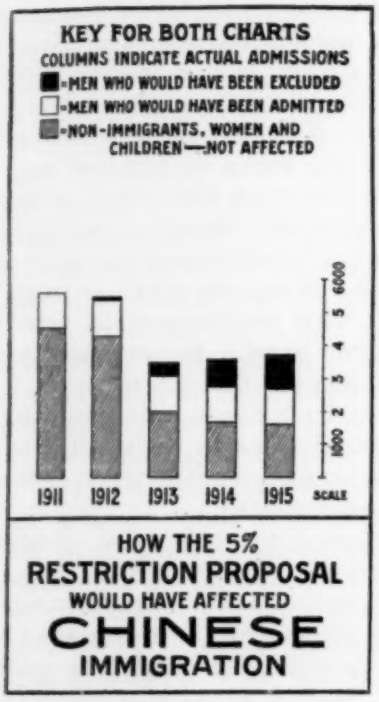
KEY FOR BOTH CHARTS
COLUMNS INDICATE ACTUAL ADMISSIONS
■-MEN WHO WOULD HAVE BEEN EXCLUDED
□-MEN WHO WOULD HAVE BEEN ADMITTED
▨-NON-IMMIGRANTS, WOMEN AND CHILDREN—NOT AFFECTED
1911 1912 1913 1914 1915 SCALE
1000 2 3 4 5 6000
HOW THE 5% RESTRICTION PROPOSAL WOULD HAVE AFFECTED CHINESE IMMIGRATION

FIG. 1.

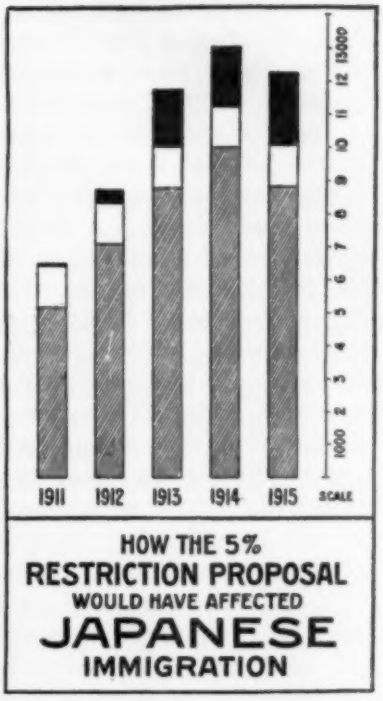
1911 1912 1913 1914 1915 SCALE
1000 2 3 4 5 6 7 8 9 10 11 12 13000
HOW THE 5% RESTRICTION PROPOSAL WOULD HAVE AFFECTED JAPANESE IMMIGRATION

FIG. 2.

same schedule for another decade. This plan does not contemplate automatic geometric increase of immigration, either annual or decennial.

(*b*) Provision should be made for certain excepted classes. Government officials, travelers and students would, of course, be admitted outside of the fixed schedule figures. Aliens who have already resided in America and taken out their first papers, or who have passed all the required examinations, should also doubtless be admitted freely, regardless of the schedule. Women, and children under fourteen years of age, should also be included among the excepted classes. If thought important, unmarried women twenty-one years of age and over might be subject to the percentage rate. By providing for such exceptions the drastic features of the proposed plan would be largely, perhaps wholly relieved.

(*c*) Should the restriction required by the five per cent. plan be regarded as excessively severe, the per cent. rate could be advanced. In any case it seems desirable that the five per cent. restriction should be applied only to males fourteen years of age and over, and to unmarried women twenty-one years of age and over.

(*d*) In order to provide for those coming from countries from which few have become American citizens, a minimum permissible annual immigration of, say, 500 or possibly 1,000 might be allowed, regardless of the percentage rate.

(*e*) Registration, with payment of the fee, might well be required only of male aliens eighteen years of age and over. Since, however, it is highly desirable that immigrant women also should learn the English language, provision might be made that all alien women should register without payment of the fee and be given the privileges of education and of taking the examinations free of cost. This privilege might extend over a period of five years. After passing the examinations there should be no further requirement for registration. If, however, after five years the examinations have not been passed, then they should be required to pay a registration tax (of say five or six dollars annually), a reduction of one dollar being allowed for every examination passed.

(*f*) In order to meet special cases and exigencies, such as religious or political persecutions, war, famine or flood, provision might well be made to give special power to the Commissioner of Immigration in consultation with the Commissioner of Labor and one or two other specified high officials to order exceptional treatment.

(*g*) The proposed policy, if enacted into law, would put into the hands of Congress a flexible instrument for the continuous and exact regulation of immigration, adapting it from time to time to the economic conditions of the country. Is it not important for Congress to take complete and exact control of the situation while the present lull is on and be able to determine what the maximum immigration shall be before we find ourselves overwhelmed with its magnitude? If the post-bellum immigration should prove to be small, a law limiting it to figures proposed by this plan would not restrict it.

(*h*) An objection to the proposed plan is raised by some. It is urged that tens of thousands would suffer the hardship of deportation because of arrival after the maximum limit has been reached. Such a situation, however, could easily be avoided by a little care in the matter of administration. Provision could be made, for instance, that each of the transportation lines bringing immigrants from any particular land should agree with the immigration office upon the maximum number of immigrants that it may bring to America during the year, the sum total of these agreements being equal to maximum permissible immigration from that particular land. There would

then be no danger of deportation because of excessive immigration. The steamship lines, moreover, would see to it that their immigration accommodation would be continuously occupied throughout the year, avoiding thus a rush during the first two or three months of the year.

(*i*) A second objection is raised by some, namely, the difficulty of selecting the favored ones in those countries where the restriction would be severe. This difficulty, however, would be completely obviated by the steamship companies themselves. Immigrants would secure passage in the order of their purchase of tickets; first come, first served.

(*j*) In order to alleviate hardship as far as possible, might not immigration inspection offices be established in the principal ports of departure, and provision be made that all immigration from specified regions should receive inspection at those offices alone, such inspection to be final?

(*k*) The most searching criticism of the policy and program here proposed deals with the percentage principle itself. It is said by critics to be mechanical and therefore artificial. Moreover, while it professes to be free from race discrimination, it nevertheless is in fact strongly discriminating, for it seizes upon the accident of a small Japanese and Chinese American-born citizenship to enforce an exceedingly rigid restriction of immigrants from those lands while it permits tens and even hundreds of thousands to come from European lands, merely because their large immigration took place decades ago. The plan, therefore, they urge, cannot be satisfactory to Japan.

These criticisms overlook certain facts. The plan takes Americanization as its foundation principle of restriction. Let the critic face this question. Is it, or is it not true, that Americanization of newcomers from any particular land depends in some close way upon the degree of Americanization of those from that land who are already here? Does a new Italian or Japanese immigrant become an American in spirit and in language equally easily and wholesomely whether the Italian or Japanese group with which he is in daily contact is well Americanized, or hardly Americanized at all? Whether they speak and read English easily and are voting citizens, or whether they speak English only smatteringly, read only their own foreign-language papers and have no voting power or political interests? If the newcomers become Americanized equally easily and rapidly under either set of conditions, then the percentage principle of limitation is artificial and mechanical; otherwise it is sociological and psychological. The writer holds

that the keeping of newcomers from any people to some small percentage of those of that people who have already become American citizens is a fundamental psychological and sociological principle, and that the proposal therefore is not mechanical nor artificial.

The admission of larger numbers than can be easily Americanized creates and maintains difficulties of many kinds—economic, political and racial. The welfare of the immigrants themselves and of the American people, and the abiding success of our democratic institutions depends upon the proper and rapid Americanization of all who settle permanently in our land.

Another fact to be kept in mind is that we must start with the present actual situation. We can not ignore or go back on history. We can no more rectify the inequalities of past immigration—Japanese or Italian as compared with English, German and Scandinavian—than we can rectify the accident of an unfortunate grandfather. We must start our new policy and program with the situation as it is to-day. We must insist that immigration from no land shall be larger than we can Americanize. This requires the admission of immigrants from different lands in different numbers, but upon the same principle. This is not "race discrimination" in the usual sense, and in the sense to which Japan raises objection.

The assertion that Japanese will resent this proposal is an assumption based on ignorance. The critic fails to understand the essence of Japan's criticism of our present policies. Japan is not demanding opportunity for free immigration. But she does earnestly ask for removal of the humiliation of differential treatment on the mere ground of race.

As a matter of fact Japanese who understand the foregoing proposals do not resent them. If all immigration to America is restricted on the same principle, that which they resent is removed, and they are satisfied. Baron Kato, then Minister of Foreign Affairs, at a dinner of welcome (February 10, 1915) to Professor Shailer Mathews and the writer, who went to Japan as the Christian Embassy of the Federal Council of the Churches of Christ in America to the churches of Japan, said: "We would not mind disabilities if they were equally applicable to all nations. . . . Questions like this require time to settle. . . . At the same time we can not rest satisfied until this question is finally and properly settled."

It may not be amiss to note that as the decades pass, if those admitted and their children chose to become American citizens,

the permissible immigration from any particular land will naturally increase decade by decade. The newcomers, however, being always kept at a small percentage of those already Americanized, the objections to and dangers from increasing immigration from those lands will be held at a minimum.

CONCLUSION

Would not the above proposals for a Comprehensive and Constructive Immigration Policy coordinate, systematize and rationalize our entire procedure in dealing with immigration, and solve in a fundamental way its most perplexing difficulties? Such a policy would protect American labor from danger of sudden and excessive immigration from any land. It would promote the wholesome and rapid assimilation of all newcomers. It would regulate the rate of the coming of immigrants from any land by the proven capacity for Americanization of those from that land already here. It would keep the newcomers of each people always a minority of its Americanized citizens. It would be free from every trace of differential race treatment. Our relations with Japan and China would thus be right.

Such a policy, therefore, giving to every people the "most favored nation treatment," would maintain and deepen our international friendship on every side.

Criticism of this plan is invited. If the reader finds himself in harmony with this proposal a letter of endorsement would be appreciated.

THE PRESENT ECONOMIC AND SOCIAL CONDITIONS AS RESULTS OF APPLIED SCIENCE AND INVENTION

By GEORGE W. PERKINS

AS recently as when our fathers were boys, Samuel W. Morse, from a room at 100 Washington Square East, New York City, flashed to the world the first message ever carried by electricity. That message was the query "What hath God wrought?" How prophetic was that query, in view of the stupendous revolution in social and industrial relations brought about since then by the use of electricity.

When miracles are mentioned our minds instinctively revert to the miracles chronicled in the Bible, and yet, with the possible exception of the raising of the dead, is there a miracle

recorded in the Scriptures that is more wonderful than the miracle of the telephone? It is a miracle of a very real, practical nature; a miracle that has revolutionized every detail of our present-day life, social, financial and industrial; a miracle that has annihilated space and brought the world so close together in its everyday relationships that we have become one small group of people, regardless of the hemisphere on which we live or the race to which we belong.

The revolution in business methods caused by the use of electricity has been so rapid and so complete as to cause bewilderment and consternation in the minds of a multitude of our people. They are fairly staggered by the mighty changes that have taken place, and I sincerely question whether they comprehend the fundamental cause of these mighty changes; and this lack of comprehension, in my judgment, is responsible for much of the unrest that permeates the world to-day. Multitudes of people engaged in their everyday affairs are seeing the results, feeling the results, without understanding the causes, for they have not been furnished by the men who have produced the causes with sufficient information as to the causes and the results which these causes are bound to produce.

The business men of the United States have been very properly charged with having been so engrossed in money-making during the last quarter of a century that they have given very little, if any, attention to public affairs; have given very little, if any, of their superb ability to public service, and have given nearly all of their ability to pursuing selfish ends, largely of a money-making nature. Much can be said to substantiate this charge, but, in my judgment, a similar charge can be made against the men of science. They have been so engrossed in the fascinating problems on which they have been working that they have taken little or no time to inform the public as to the practical effect that modern scientific inventions were bound to have on the everyday lives of our people. These inventions have been placed in the hands of the people of the world within the last third of a century, and their application to business and social affairs has overthrown and carried away a countless number of old practises and precedents. The result has been a mighty conflict between the old laws of man and the new laws of science. One or the other had to give way. As the man-made laws were the outgrowth of centuries of effort and cumulative human knowledge, it did not seem possible that anything could come into the world that would set all this cumulative knowledge and experience to naught, and do it overnight, as it

were. Such, however, is the actual situation, but a vast majority of the people of the world do not realize this, do not at all understand it. It is also true that even a large number of our more intelligent men have refused to accept the new conditions in which we live and have insisted on continuing under the old system, following old precedents and practises. As a result, a mighty conflict has engaged us and will continue to engage us until our people and the other peoples of the world realize that a mighty upheaval has taken place; that we have entered a new world of thought and action, dominated almost wholly by the discoveries of science within the last half century; that new codes of business morals, of finance, of industry are being set up, and that it behooves us all to give the best thought, the broadest vision, the most unselfish devotion to the erection of a new structure that will be in harmony with the modern economic needs of our people.

Who can be of more help in this great reconstruction period than the scientist? Should he not, in the present troubled and confused thought of the world, give of his thought and his time to the work of informing the people in simple, easily understood language as to what he has done to upset our old practises and customs? Should he not tell them wherein his work and accomplishments will be of benefit to the people and why? Should he not show them how impossible it is to follow old precedents and practises when he, the scientist, has by his discovcoveries and inventions completely wiped out old methods; when he, the scientist, has, through the miracles he has wrought, destroyed old tools and substituted new ones? Until the people as a whole fully realize this it is going to be most difficult to readjust our minds sufficiently to make us capable of rearranging our social and industrial practises.

The bitter conflict that has been waged in our country during the last twenty-five years between the old laws of man and the new laws of science has been caused by a lack of understanding on the part of our people as to what has been going on. I believe that a half century from now—yes, much sooner—our people will look back at the struggle in which we are engaged and marvel at our shortsightedness. They will look upon it then much as we nowadays look upon the witchcraft of early New England days.

For the last twenty-five years the scientist and the inventor have almost daily placed in the hands of the merchant and the manufacturer some new instrument or device that has made it possible for him to speed up his business and reach out and do

business at far distant points; some device that has made it possible for a single human mind to do infinitely more business than any human mind ever did before. As soon as the business men began to employ these devices, our old man-written laws of a quarter or half century ago were invoked to prosecute these men who as a matter of fact were simply using, in their practical everyday work, the discoveries of science and the instruments of the inventor.

How perfectly absurd it is to allow a man to invent a machine, to applaud and honor him for such invention, and the very next instant attempt to place behind the bars the business man who uses that invention. This is precisely what our country has been doing for a quarter of a century. The telegraph that Mr. Morse invented and the telephone that Mr. Bell invented have been acclaimed as the great discoveries of the age, and these men have been hailed everywhere as great benefactors of the human race; yet had it not been for these two inventions, how utterly impossible it would have been ever to have had an interstate corporation or a so-called trust. Our politicians have told us that the tariff made the trusts. They seem to have forgotten that while we have had a tariff in this country for more than a hundred years, we have only had large interstate corporations for a matter of thirty or forty years. Intercommunication, improved and developed through the use of electricity, has been the underlying cause of the great industrial interstate and international enterprises. Raise or lower the tariff as much as you please and leave modern intercommunication undisturbed, and your great interstate and international industrial unit of to-day would continue; but take away that strange force which we call electricity and your interstate and international business concern would fall to pieces in short order. The telephone, not the tariff, made the trusts.

Intercommunication is the first requisite for doing business. In our grandfathers' day there was no concern larger than that of the store owned and operated by one individual, for the simple reason that an ox or horse team could not go very far and they were the only methods of intercommunication. Intercommunication has rapidly improved, thanks to the marvelous work of the scientist and inventor, and as it has improved and extended business has grown from the individual to the firm, from the firm to the company, from the company to the great international corporation. The only way to stop this development, to set it back where it was in our grandfathers' day, is to eradicate the causes that have produced the results.

My plea is that our people be told all this in plain everyday language; that they be told it by you, the men who are so largely responsible for creating the cause that has produced the result. Until our people understand the fundamental cause, we are going to have a conflict of titanic proportions. A campaign of education is therefore imperative, for much that we learned in our youth must be consigned to the scrap heap, discarded altogether. We must learn new methods of thought and of action. In order to do this our people must have the facts. We can not expect them to readjust their thought and their action to such a great extent as they must without facts that are indisputable. Who can give them these facts better than the men who have created them—the scientist and the inventor?

Steam and electricity have been the great unifying forces in business. With their advent it became perfectly natural for men to reach out and command larger areas of trade, to have great practical visions of interstate and international conquest in trade. The people as a mass do not understand this. They almost feel that supermen have come into the world in the last quarter of a century, men of far greater mental ability than ever existed before. This of course is not true. The men of the last quarter of a century have accomplished what they have not because they were endowed by the Almighty with vastly better mental machines than their fathers possessed, but because they have been endowed by the scientist and the inventor with vastly better material machines than their forefathers possessed. If our grandfathers wished to talk to a man in the next block they had to put on their hats and go and hunt the man up. If a man living in Boston wished to talk to a man living in San Francisco he had to transport his body across the continent before he could do it. To-day all that is necessary is for you to turn in your chair, pick up a tiny instrument and command the voice of your friend whose body is on the other side of the continent, and his voice immediately sounds in your ear.

The Germans were the first people who had sufficient vision and courage to comprehend what mighty and practical changes the scientist and the inventor had wrought in business methods. They lost no time twenty-five years ago in shaping their future to be in keeping with the great new electrical age upon which the world was entering. They formed large trading companies and with great rapidity abandoned the old axiom "competition is the life of trade" and substituted the new slogan "cooperation

is the life of trade." With this slogan they went out for the trade of the world. At the same moment our country took exactly the opposite course and, through the passage of the Sherman Law, declared that competition was and must continue to be the life of trade.

Japan is another country that has lost no time in throwing off the customs and precedents of the past and entering the great new electrical world with broad vision and splendid courage. Witness what Japan has accomplished in less than half a century. She has cast off the customs and precedents of centuries and reached out with great eagerness for the newer and more advanced thought of the world. She has sent her best young manhood to the universities of all the civilized countries. She has sent commissions of her most able men to all points of the globe, that they might bring back the best thought and most advanced practises in social and business relations. For the last quarter of a century precedent has meant nothing to Japan. She has thought only of the matchless opportunities that are opening to the world because of universal education and vastly improved methods of intercommunication.

In both Germany and Japan the government has worked hand in glove with its merchants and manufacturers, leaving no stone unturned to make it clear to their people that the customs of their fathers and forefathers were things of the past and that new beliefs, methods and practises must take the place of old ones.

We pride ourselves on being a new country, a progressive country, free from the shackling influences of precedent. As compared with Germany and Japan and their accomplishments of the last quarter of a century we are an old benighted country. While both Germany and Japan have been reaching out into the future with new methods and practises our so-called statesmen and laws have tried to bind us hand and foot to an archaic past.

Fifteen years ago some of our business leaders with vision and courage attempted to organize the railroads of our great Northwest into one company, and planned to connect that railroad system on the Pacific coast with a line of steamships to Japan and China. Under an archaic law our government attacked the enterprise, declared it illegal and prevented its being carried out. The project was abandoned and the ships for the Pacific were never built. Later on the La Follette Law was passed, which effectualy disposed of the few ships we had remaining on the Pacific Ocean, and to-day in place of our being

a potential factor in the carrying trade of the Pacific we are a negligible quantity, while Japan, whom many of our people still regard as an ancient nation, has forged ahead and practically taken possession of the carrying trade of the Pacific. All this is largely due to an utter lack of understanding on the part of our so-called statesmen and our people as a whole as to the great economic changes that have been brought into the world, not so much through the selfish desires of business men as through the potential achievements of science.

The modern commercial accomplishments of Germany are too numerous to mention, but the latest one of which I know is the creation in Berlin of what is known as a Federal Purchasing Bureau. I understand that hereafter when a merchant in Germany wishes to purchase some commodity that is to be procured outside of Germany he will be required to go to this purchasing bureau of the government and lodge his order. Take copper for instance: If the Germany copper merchants wish to buy copper they will each go to the government purchasing bureau and lodge their respective orders for, say, May copper. When the orders are all in this purchasing bureau will go out into the world to buy, say, fifty million pounds of copper. It will naturally come here, for we produce such large amounts of that metal. When it comes here it will find that our laws require that our copper merchants compete with one another in the sale of copper, while the German law requires that their merchants cooperate with one another in the purchase of copper. The method of Germany is, therefore, exactly the opposite of our method. Which is right? If Germany is right, then she is acquiring from us one of our most precious metals on terms very advantageous to her and very disadvantageous to us.

Twenty-five or thirty-five years ago, before science and invention had perfected electrical intercommunication, such arrangements as these did not and could not exist. But to-day they can and do. Not only this, but in the judgment of all thoughtful men they are but in their infancy, for science and invention are making stupendous strides in perfecting instantaneous intercommunication of thought and the more rapid transportation of our bodies and commodities from point to point. When this war shall have finished the conquest of the air will have been accomplished. The wireless will be a practical everyday instrument. The submarine telephone will doubtless be in operation, and international lines will then mean about as little as state lines mean now, all because of what science has accomplished.

Surely you men of science have vast accomplishments to your credit. You have reason to be exceedingly proud of a great record of achievement; but is it not high time that you did your bit by making it plainer to the people as a whole what your accomplishments mean to them in their work-day lives, making them understand that while you have destroyed an old order of things you have created a new and better order of things. Would it not be highly beneficial to our country if some of your meetings and discussions were given over almost wholly to the task of enlightening the people as to why it is that old methods must be discarded for new methods? Will you not give your splendid talents to plain talks with the multitude, for a great crisis confronts the world. It is the crisis of changing in a night, as it were, from the age of the ox team to the age of the flying machine. Certainly no such stupendous revolution has confronted the world in all its history, and unless our people can comprehend it all, can understand it all, they will not be qualified to deal with it in their homes, in their business and, above all, at the polls where representatives are selected by them to make new laws and discard old ones.

THE FINANCING OF PUBLIC UTILITIES

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A FUNDAMENTAL factor on the economic side of the management of every public utility is that provision must be made for a constant supply of new capital.

When a new plant of a public utility has been completed, it has not been completed; in fact, its construction has just commenced. It would be a most exceptional situation if such a plant were finished before it had become necessary to consider and provide for additions to it. The communities which these utilities are serving, whether the utilities are local or more than local in their character, are constantly growing. This constant growth necessitates constant additions to the plant. The utilities can not stand still. Unless they go forward, they will go backward. It is absolutely essential not only to the public welfare and convenience, but also to the success of the utility itself that it meet these constant demands promptly. A failure to do this means inadequate and insufficient service

which usually causes and, unless it be due to extraordinary and abnormal conditions, justifies public dissatisfaction, criticism and controversy, with all of the losses and embarrassments to the utility and the public which they directly and indirectly involve.

Every well-managed public utility recognizes its obligation to meet these demands as they arise and to anticipate and provide for them in advance, so far as this may reasonably be done. The definite determination of what these future demands will be in any concrete case, in the nature of things is involved in more or less uncertainty; and where this uncertainty is such as to render the investment unjustifiable it imposes a necessary limitation upon construction in advance of known requirements. As to every utility, the correct engineering point of view, because it is the correct financial and economic point of view, is always with reference to the future. If the property is a well-managed property, speaking broadly, the work that is being engineered and financed to-day is normally with reference to future requirements; the plant that is in use to-day, meeting present requirements, was engineered, financed and constructed in the past.

The magnitude of the investment in these utilities and of this persistent demand for new money is seldom appreciated. The statisticians inform us, using the figures for 1916, that the investment in the principal utilities of the United States, including steam railroads, telephones, telegraphs, street and electric railways, electric light and power plants, water transportation, express companies, the Pullman Company, manufactured and natural gas plants, water plants and pipe lines, aggregated more than thirty-two billion dollars. It is said that during the last five years, the additions to this investment have, upon the average, amounted to more than one billion dollars in each year. This figure is too low to be taken as the basis for determining the amount of money required for these purposes. It is well known that during this period, the additions to railroad plant and equipment have not been sufficient to meet the public requirements.

It is scarcely necessary to refer to the fact that these additions can not be provided out of surplus earnings. Such earnings can and should provide a part of them, but they can not be relied upon as the sole or as the principal source from which the new money is to come. It must be attracted to these investments from the body of surplus capital which is at the time seeking investment.

Another fundamental fact, so obvious that there would be no excuse for alluding to it if it were not very frequently overlooked, is that basic economic laws require that there shall be paid for this new money what it is worth in the money market.

This general market to which the public utilities and all other enterprises desiring to obtain money must go, is in the very nature of things a highly competitive market. Those who have money to invest will invest it where, all things being considered, it will bring to them the highest return. It will go to the highest bidder. Investments in public utilities, just exactly like investments in real estate, manufacturing, banking and everything else, must be attracted by a prospective profit, and this profit, taking into account hazards and other conditions, must be equal to that offered by other available investments. Otherwise, the investors, who are seeking a profit, will place their funds in the more profitable enterprises and the money will be diverted from public utilities. To secure normal, natural business conditions, the profits to be derived by the investor from the various channels of investment must be equal when the variations in hazards and other material conditions are taken into account. When this equality exists, each class of investments will normally secure its proper proportion of the general supply of money. If one class of investments is temporarily more profitable than another, money will flow into that class until, through the operation of the laws of demand and supply, it is brought into its proper relation with the others. The late Professor William G. Sumner once said that in the final analysis returns from government bonds and gold mining must be equal.

The contention that because capital invested in public utilities is devoted to a public use, it is therefore not entitled to relatively the same return as capital in private investments, the conditions, hazards and other factors affecting the investment being considered, will never be sound as long as the laws of demand and supply remain effective. The man with a thousand dollars, or five thousand or ten thousand dollars to invest will not put it into securities of public utilities, no matter what he may reasonably believe they will earn in the way of a return, if at the same time there is offered to him an opportunity to invest this money in other securities equally sound which will bring to him a greater return. This attitude on the part of the investor is not only a cold, hard fact, but it is right. There is no legitimate reason why the business of furnishing the public the service which it requires should not be upon a sound,

economic basis. The same reasons which compel public utilities to pay the market prices for what they require of labor and machinery and iron and copper and other materials, and coal and oil and other supplies, require them to pay the market prices for money. It would be as legitimate—and no more futile—to argue that the labor used by utilities should be furnished at less than the market rate because in a public service, as it is to apply this argument to capital.

Because the fundamental economic laws of supply and demand apply to money just as broadly and effectively as they do to everything else, there has not been and there never will be devised any plan or any scheme under which, speaking broadly, public utilities can be enabled to obtain the money which they require for less than it is worth. To assert that this should be done, either in the case of capital or in the case of labor, is to assert that these services, which are of such value that they have become absolutely essential factors in our social and business life, should be furnished to the public for less than cost. This would amount to a denial of their economic right to exist. From the economic point of view nothing has a right to be unless it can pay its own way.

Because this money must be obtained in a competitive market, where the investor is not limited to these investments but may do with his money what he pleases, and will and should make the disposition of it which in his judgment promises the greatest profit, in the final analysis it is the investor who determines what return will induce him to part with his money, and therefore what return the public utility must pay in order to obtain this money. It is the investor who has the money to sell. It is he who actually fixes the price which will induce him to part with it. The investor is the public, or a very considerable and influential part of it. The opinion of every investor, from the savings-bank depositor to the holder of millions, is an element in this determination; so that it is the public itself which fixes the return which will attract money to its service.

It is clear from what has been said that in considering what is a fair return upon money invested in public utilities, or in any public utility, the question must be approached from the standpoint of the requirements of new capital to provide the necessary additions to plant. Much of the discussion of this question has been predicated upon the assumption, sometimes unconscious, frequently not stated, but very frequently present and underlying the whole argument, that the investment in a

public utility, once made, is fixed, and that the question presented is what should this utility fairly and equitably earn upon this fixed investment. This is inherently wrong, because it is directly opposed to the fact that the investment in a utility is not fixed and is not completed. It is inherently wrong, because the concrete fact with which these utilities must constantly deal is the rate that must be paid for new money.

The return which will attract to these investments their proper proportion of the available money seeking investment is that return which will place them upon a parity with other enterprises, and which is therefore a fair return.

The public utilities of the United States are much regulated. Within the last few years, commission laws have been enacted until now in every state except Delaware there exists a state commission, exercising more or less jurisdiction over the utilities within its territory. The Interstate Commerce Commission has jurisdiction over interstate carriers, including the telegraph, telephone and express companies. The jurisdiction of these commissions varies, but in general it embraces the matters of rates, service, accounting and capitalization. In addition to these larger regulatory bodies, it is probably true that there is no state which has not delegated to its municipalities greater or less power to regulate public utilities.

For the purposes that I have in mind to-day, it is not necessary to hold a brief either for or against regulation. Personally, I favor it because I believe that regulation, notwithstanding the fact that it is still in the development stage and has as yet by no means worked out to perfection, will in the long run be better for the public and better for the utilities than no regulation. But regulation costs money. It involves direct expenses to the public and expenses that may be called indirect; because in the final analysis the expenses of the utilities on account of regulation must be repaid by the public as a part of the expenses of their operation. To justify itself, regulation must be worth more than it costs. It can not be a benefit to the public unless it is also a benefit to the utilities. They are so closely interdependent that what helps or hurts one similarly affects the other.

The recognition of the two fundamental propositions which have been under discussion will go far toward realizing sound regulation of financing by public utilities. That the public requirements must be met and that the public must pay for what it receives are inevitable. It is indisputable that the requirements which the public imposes upon every kind of service af-

forded by public utilities are constantly growing and that this growth must continue. Sound regulation must recognize this fact and must recognize the necessity for providing the additions to plant required to adequately take care of this continuous growth. These are facts which can not be affected or controlled by laws, or by decrees of courts, or by the enactment of orders by regulatory bodies, whether they be state commissions or municipalities. Any attempt at regulation which does not recognize this limitation upon the power to regulate is in this respect unsound.

I am not familiar with local conditions in Pittsburgh. I am confident, however, that out of the growth of its population, out of the enormous increase of its business due to the war, there has arisen an increased demand upon every utility serving this community, upon the telephone service, the telegraph service, the railroad service, the water service, the gas service, the electric-light service, the street railway service, the express service, and others. What I have attempted to emphasize is that this demand is due to conditions over which no commission or regulatory body can possibly exercise any control. It is something that can not be affected by any action or by any order of any constituted authority. If it has not been anticipated, if the investment necessary to take care of it has not been made—and it is not believed that it was humanly possible to foresee and to adequately provide for existing conditions—then there has resulted some impairment of the service, with some inconvenience and loss, which must continue until the abnormal conditions incident to the war will permit the necessary readjustments. What is true of Pittsburgh is true of every other community and of the country as a whole.

It is just as true that it is beyond the power of regulation to say what shall be paid for money. There is some loose talk on the part of commissions, and more on the part of those who appear before them, about what the commissions or the laws under which they are created will permit the utilities to earn. This is all based upon misapprehension. What rate of return will attract new capital to these utilities is a question of fact to be determined by the application of sound judgment to all of the material evidence, just as much as the value of a piece of real estate, or the value of the property of a telephone company, or a water company, or a gas company, is a question of fact. What the legislature, or commission, or municipality can do, and all that it can do, is to determine this question of fact. Their authority goes no further than to authorize them to ascer-

tain as accurately as they can what return will appeal to the public as sufficient to induce the investment of money in these enterprises. If this question of fact is determined correctly, new money will be forthcoming; if the conclusion is too low, it will not be forthcoming: and since the regulatory body has no power to compel the public to change its opinion, it will be necessary for the regulatory body to revise its own conclusion.

With the recognition of these two fundamental propositions by the public and by the regulatory bodies, the foundation is laid for sound regulation of public utilities from the financial standpoint. It is fortunate that they are neither difficult to understand nor inequitable in their results. Every one, no matter how limited his attainments, can readily appreciate and easily comprehend that increases in population, increases in business, and developments in the services of the utilities which broaden their usefulness, all tend to create a necessity for more plant and for more money to create this plant. Again, to reverse a homely phrase, they all understand that in this situation foresight is better than hindsight; it is obvious that foresight in the provision for these growing demands means the greatest efficiency and least interruption in the service.

To demonstrate that to induce money to flow into these enterprises they must appeal to the investor as offering him as much in the way of profit or return as is offered to him by other investments taking into account hazards and other conditions, is just as easy. All that is required is to put yourself in the place of the investor and to ask yourself which investment you would choose for your own money.

The equity in what these propositions involve is plain. They contemplate that the public shall have the service that it wants when it wants it. They contemplate that the public shall pay for this service what it is reasonably worth. The service is indispensable and is worth much more than the public can ever be required to pay for it.

Because these propositions are simple and are equitable, I believe that the public generally will accept them, just as soon as they are brought to its attention so that it understands them. Speaking broadly, I do not believe that the public generally either wishes to or believes that it could obtain these necessities for less than a fair remuneration. It knows that it can not obtain something for nothing. It is willing to pay a fair price. The essential thing is that it understand what is a fair price.

SCIENTIFIC CRITERIA FOR EFFICIENT DEMOCRATIC INSTITUTIONS

By Professor ALBERT H. WRIGHT

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IN recent years the American public has been treated to much heralding of the advent of efficient government. Ballot changes, civil service reform, investigations of research and efficiency bureaus, proposals for more businesslike administration of public office and devices for giving freer expression to the popular will have been offered at various times. Severally they represent faith in the punishment of wrongdoers, confidence in the methods of private business, or trust in the wisdom of a powerful electorate, for the development of sound and satisfactory government. Excellent as some of these proposals are, they furnish no answer to grave questions which have been forced on democracies in recent months. What is the aim or goal of democratic government? Can democratic government survive the rude shock of a great public trial? How may it escape the dangers due to conditions bred of its chiefest virtues? How may it, in a social order as yet imperfectly understood, find the knowledge and the method requisite for the formulation and prosecution of social policies vital to its continued existence?

For our American democracy we have at the least the first of these questions answered. Whether by reference to the operation of government, the pronouncements of party leaders, or public opinion we shall find that the maximum possible of personal liberty and individual opportunity constitutes the aim and justification of our political life. It needs no demonstration that to secure and maintain this condition for all citizens our governmental institutions are put under the duty of developing the material and social resources of the land to the full. It is fairly evident that our present political institutions as they function do not satisfy this ideal requirement. It may be feared that they are ill prepared to face confidently any of the issues in which the continued existence of democratic government is at stake. If the politician and the statesman have failed us, what resources of leadership have we remaining? What more natural than that the social scientist should feel that he should be the guide?

Subject to the sometimes narrow limits of political expediency our governments, local, state, and national, have accepted

the standards of the physical scientist. But the social scientist finds discouragement everywhere. His technique is new, his knowledge is tentative, his method is untried. He may not aspire to the precision of older sciences. His statements are liable to gross misinterpretation as they encounter ingrained beliefs, prejudices, wilful ignorance and resentful selfishness. As if to minimize his efforts the inadequacy of his information forces him to extreme modesty in his claims. Who, for example, would dare set up a standard for population increase? What view on the immigration problem shall prevail? What shall be our decision as to the distribution of social income? There is hardly a matter of major interest to our democracy for which social scientists may claim even tentative standards.

Insufficient knowledge is, of course, no rightful objection to the leadership of social science, if even that knowledge surpasses any other and gives promise for the future. A serious obstacle will be encountered when that leadership is asserted. Those in charge of our governments do not frequently seek the advice of the social scientist. A widely disseminated suffrage furnished a fertile field for the development of the professional politician. The politician responds to the interests, influences or groups which maintain him. The disintegration of government makes the politician necessary to harmonize outdated political institutions with modern social and economic creations. The politician champions fervently the further extension of the electorate that his own position be made more secure. Scientific leadership in politics must await the reconstruction of our political mechanism.

As an accompaniment to the remarkable material progress of the past fifty years we must note the unfortunate, steady deterioration of government, not alone in quality, but in power as well. It is a commonplace of recent American history that from the close of the Civil War to the end of the nineteenth century Americans were so intent upon the conquest of the resources of the country that they neglected public affairs. It was this period which gave over the governments of the country to the professional politician. Other contributing influences may be traced. Certainly a share of the responsibility goes to the inventions which facilitated transportation and communication, thus causing those in charge of these expanding media of commerce to regard state boundaries as artificial obstructions to be surmounted in the interest of developing industry. Likewise, the influences which caused the gradual concentration of the production of certain articles of manufacture

within the limits of a small section, sometimes a single state, helped reduce the power of government. The development of large-scale production, the integration of industrial processes, the concentration of credit control in a few centers, and the growing use of the corporate form of organization all assisted to weaken local governments, obliterate state lines, and render the federal government, to a degree, helpless. The weakening of government was inevitable. Industry grows, rewards, interests, directs. It mingles intimately with the citizen's life. Its returns are tangible and immediate. Business organization responds quickly to demands for change. Our governments are still permeated with eighteenth-century concepts, their organization in part is of the same derivation. Governments move slowly, change seldom, reward poorly. On demand for change they await the slow coalescence of public opinion. It could not have been otherwise than that industry should have loomed large in the popular imagination, that it should have enlisted popular interest and that government the while should have suffered increasing obscuration. Consequently when industry used the politician to turn the creaking wheels of government in its interest, every social or economic group with a vestige of power turned to the same practice, thus making the politician fairly secure.

Rightly or wrongly, political stocktaking will show us a national government restricted in power as is no other great national government because based on a constitutional system constructed in apprehension of rather than in confidence in democratic institutions. We shall find our state governments monotonously alike in their main outlines, and largely based on obsolete constitutional principles. Some local governments we shall find responsive to democratic impulses, but many more restricted in power and at the mercy of the state legislature. The entire system is managed by party leaders who must placate supporting interests and who rarely dare disinterested public service. Before executive officers and legislators, who hold office by the caprice of popular election, press various groups seeking protection for their class interests. Legislation and administration reflect class demands. Governments thus become mere prizes of power and their results, spoils, concessions, or compromises.

Hardly an encouraging outlook for the efforts of social science! Seemingly a double duty is enjoined. The student of social science must continue his study of social phenomena for the evolution of definite standards for social action. At the

same time he must strive for the creation of conditions which will afford opportunity for the development of his leadership. Such action is, clearly, not the sole prerogative of the social scientist, but he must assume a leading part in the forward movement.

What can be done? How can a democracy be persuaded to change its habits? What changes will bring the promise of scientific leadership? Leaving aside the familiar contention that popular education through the shaping of public opinion will achieve the desired end—an optimistic outlook of doubtful value—we may suggest some few changes which will make less difficult the reshaping of democratic government. Undoubtedly one favoring condition for the professional politician lies in the ease with which the privilege of the suffrage may be secured and used. When the indifferent, the uninformed and the incapable voters determine election results for the benefit of the political worker patriotic intelligence is placed under a heavy handicap. This evil might be minimized by (1) requiring of both naturalized and native citizen preliminary training for the initial use of the suffrage, (2) by the elimination of mentally subnormal voters by appropriate psychological tests—if competent for school children and soldiers why not for voters—and (3) by basing registration for elections on the voter's knowledge of the issues or candidacies involved in the forthcoming contest. Perhaps we may take a lesson from ancient Athens, whose youths began civic responsibilities at eighteen but gained political privileges only gradually thereafter, reaching full privileges at thirty. The vote will be prized only when it is worth prizing. From an intelligent electorate may we not expect conscientious service and a chance for educated leadership?

To-day the fitness of an elected official for the duties of his office is a matter of pure chance. Indeed, candidates have been rejected at the polls for apparently no other reason than that they were competent. This seemingly hopeless condition may possibly be remedied in some degree in the future if universities undertake the training of young men of executive promise who desire to enter public service for the definite purpose of seeking public executive positions which offer the chance of determining political policies. It should be possible thus to train local leaders to compete with local politicians on more than equal terms.

For our present legislative lottery must be substited something better. At present any member of a legislature can in-

troduce measures at will. No important bill can be considered until several rival measures have been pigeonholed. Even then the bill is subject to the tender mercies of committee action, proposed and actual amendment when before the whole body, change in the other house of the legislature, the compromises of a conference committee and possible executive veto. The executive's program of legislation should be given the right of way. The bills should be drafted by an expert draftsman working under the direction of a committee of competent authorities on the subject-matter of the measure. Amendments should be permitted only with the consent of the drafting committee. When it is recognized that legislation is a science we shall be well toward an efficient democracy.

Finally, constitutional changes should be constructed in quite different fashion from present methods. Reverence for custom and imitation may have their uses, but they are hardly reliable guides for the reconstruction of government. Piecemeal change has slight justification, if a single gain is used as an excuse to preserve several outworn practises. Periodically the whole social and economic structure of the governmental area should be examined, the standards and desires of all groups ascertained and then a governmental organization be framed in the light of this information for the realization of democratic aims without regard to the fate of the old framework. We should cease trying to make society conform to what a few consider correct government, and instead mold our government to conform to the facts of society.

If, throughout our operation of political institutions we advance patiently to the acceptance of the experimental attitude and the method of social diagnosis as our basis of action, democracy may presently be safe for scientific standards.

RAILROAD FINANCE FROM THE STANDPOINT OF EFFICIENCY

By Professor HOWARD C. KIDD

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IN studying the problems of railroad finance and credit, there are two angles of approach: rates and costs. The first is in the hands of the Interstate Commerce Commission; the second is in the hands of the railroads.

The solution of the financial problem through increased

rates seems hopeless, because there is little probability that the Interstate Commerce Commission will grant a substantial rate increase. Even if the roads were granted all they ask, it would not be long before they felt the effect of the "vicious circle" of costs rising at a faster rate. Their relative position would register no improvement. It is a case of lifting yourself by your bootstraps.

The solution of the problem by cutting down costs is the only course open to the roads. It is a question of efficiency and scientific management of present railroad equipment. Economy of operation is forced on the railroads because of abnormal traffic volume at a time when they are short of labor and equipment. In the first six months of 1917, American railroads handled 14 per cent. more freight than during a corresponding period of 1916, and 50 per cent. more freight than for the same months of 1915. In the same period the railroads added to their equipment 1 per cent. new mileage; 2 per cent. new locomotives; 3 per cent. new freight cars. This disparity between traffic demands and new equipment has compelled the railroad managers to study intensively the best improved methods of operation.

To meet the new traffic conditions, railroad policy has been directed in order to secure two general results: first, unified and central executive control; second, maximum efficiency in the use of labor and equipment.

The desire for a policy of centralized control is not new as far as the railroads are concerned. The approval of the government, however, is a decidedly new attitude. The railroads have been attempting a scheme of pooling or consolidation since the period of cut-throat competition and insolvency in the '70s. First the pooling of earnings was tried, but declared illegal by the Interstate Commerce Law of 1887. Then the roads resorted to the pooling of traffic. This practise was outlawed by the application of the Sherman Anti-trust law of 1890, applied to the railroads in the Trans-Missouri decision in 1897. The railroads then tried the pooling of securities, but here again they were checkmated by the ruling of the United States Supreme Court in the Northern Securities case. The last attempt at consolidation has been the recent attempt to pool equipment in Trunk Line territory. If it had succeeded, government operation of the roads during the period of the war would not have been necessary. The failure of this pooling arrangement seems to have been due to confusion arising from the conflict of orders given both by the government prior-

ity committee and the committee representing the railroads. The policy adopted by Mr. Wilson of operating the railroads of the country as a unit should produce maximum efficiency of operation, and also safeguard the financial interests of the investors.

The solution of the present railroad problems, however, can not be reached by merely centralized control, much as such a scheme may help. Greater efficiency in the use of present railroad equipment must be quickly developed.

A few years ago, Mr. Louis Brandeis made the statement that by the use of up-to-date methods of handling labor, and the application of practical science in working their plant, the railroads of the United States could save $1,000,000 a day. Whether the remark was true or not, the railroads within the last few months have learned the value of scientific management in such matters as packing, handling freight at terminals, loading cars, and especially in generating locomotive power.

With regard to packing, the railroads, in cooperation with the shippers of the country, can effect great saving of space, which will, of course, reduce unit costs of operation. As an example of the need of improvements in packing, the cotton situation might be cited. A recent article which appeared in the *Textile Recorder* of Manchester, England, points out that the present density of the United States bale is 22 pounds; the Egyptian 37; the Indian and Chinese from 45 to 60. The article concludes that, were the American compress methods more improved, a saving of vessel cargo space would total 9,305,000 tons dead weight. The argument which applies to vessel space could be drawn with equal force to freight-car space which could be utilized to relieve the present traffic congestion.

In the matter of loading cars, the roads have effected substantial economies. Comparing the first six months of 1916 and 1917 the railroads of the country increased the average carload from 24.4 tons to 27 tons. This savings is equivalent to adding to the rolling-stock equipment 200,000 freight cars.

The improvements in handling "less than carload" shipments have been especially noticeable. Fairfax Harrison, chairman of the Railroads War Board, recently issued the following significant statement:

> On 77 of the principal railroads of the United States, a saving of 114,109 cars was effected in one month this year solely by increasing the "less than carload" freight. The reports show that the average loading for that class of freight during July this year was 13,927 pounds, as compared with an average of 11,619 pounds during the same month last year.

At seaboard terminals, where congestion is greatest, efficiency in freight handling is being developed. At the Pennsylvania R. R. piers, New York, located on the North River, mechanical improvements in recent years have reduced the cost of handling bulk freight, such as coke, coal and limestone, from $.56 to $.04 per ton. A 12,000-ton steamer can be loaded in twenty-three minutes. However, in the handling of mixed cargoes, methods had improved very little within the last fifty years. Recently the use of the electric tractor, to which is attached a train of four or five trailers, has produced results very satisfactory in comparison with the use of hand trucks. The speed of the hand truck is approximately one mile per hour; that of the tractor-train is about 4 miles per hour. The following comparison indicates the relative saving of work:

Packages	Weight	Trailers	Equivalent in Hand Trucks
40 boxes, oranges	31,200	3	10
102 half chests of tea	7,650	5	25
12 cases, tobacco	2,520	3	12
146 packages, groceries	3,400	4	29

Possibly the place where railroad efficiency can be promoted to the greatest extent is in their locomotives. It is estimated that of the 63,500 locomotives in use on American railroads, only one third are mechanically modern. To make the two thirds modern would require an average expenditure of $3,000 per locomotive, involving a total expense of $120,000,000. The result would be an increase in general equipment capacity of about 33 per cent. To increase capacity to this extent in any other way would probably cost about thirty times this amount, or $3,600,000,000. Even if the steel and labor, necessary for such enlargement, were available, the present condition of the money market would make such financing impossible. President Markham, of the Illinois Central R. R., has pointed out that as a result of mechanically improving the locomotives on his line, an average freight mileage of 40 miles per day has been reached. Just what this achievement means will be appreciated when it is remembered that the average freight mileage for the United States is 29 miles per day.

The possibilities of the electric locomotive are being seriously investigated by railroad men. Mr. F. H. Shepard, of the Westinghouse Electric and Manufacturing Company, says that the "electric locomotive of to-day, in its ability to handle the heaviest trains in congested service, to make long sustained

runs and to remain continuously in service, has demonstrated its unquestionable superiority over any method of steam operation."

The electric locomotive has probably had its best test on the Chicago, Milwaukee and St. Paul, where it has been tried out on 226 miles of difficult grade on the Rocky Mountain Division. Vice-President Goodnow sums up the following advantages of electric compared to steam locomotives:

1. Higher efficiency in cold weather.
2. Has made double tracking unnecessary.
3. 11.3 per cent. of the power consumed has been generated by trains on down grade.
4. Greater ease and safety in handling trains on grades, involving less wear and tear on equipment.
5. "Dynamic breaking," or the holding of trains at uniform speed on down grades without the use of air brakes.
6. Longer and heavier trains.
7. Greater speed.
8. Possible elimination of round-houses.
9. More work from one half the number of locomotives.

The possibilities of generating electric energy by the use of water power is another item in favor of the use of the electric locomotive. One fourth of our coal supply is consumed by the railroads. The substitution of any other source of power would not only solve a vital problem for American railroads, but also have far-reaching industrial effects in the period of reconstruction which must follow this war.

In conclusion, the following interesting statement regarding the problem of railroad efficiency was made a short time ago by Mr. Henry Ford:

> The freight car weighs as much as the load it carries. Heavy cars require heavy engines, heavier rails, greater strains in starting and stopping, more coal, heavier bridges, and the result is increased waste and depreciation. Four fifths of a railroad's work to-day is hauling the deadweight of its own wastefully heavy engines and cars.
>
> Nature has distributed alloy materials which, with heat treatment, make steel of 150,000 or 200,000 pounds tensile strength, instead of 50,000, and then the weight can be cut down proportionately. Alloy steel of high tensile strength cuts down the weight.

Whether the railroads remain in the hands of the government, or are returned to their present owners, the problem of efficiency along the general lines suggested above, must be studied by operation and traffic managers. An unprecedented traffic crisis, which will continue indefinitely after the conclusion of peace, calls for rigid economy and intelligent cooperation.

LABOR CONDITIONS WITH REFERENCE TO THE WAR

By Professor FRANCIS TYSON

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WHAT of the labor shortage? The question is on the lips of many war leaders and most business men. The American labor supply seems less adequate to meet the demands than ever before in our development.

From the West come dire predictions of failure of our aims of feeding our Allies if we do not effectively increase the agricultural labor force. Greater acreage or more intensive cultivation will require more labor. The fuel administrators and mine operators face a real labor shortage as well. Western Pennsylvania is asking now for miners. Continued and increased production is needed to keep our furnaces and factories supplied with fuel. The exhaustion of the railroad labor reserve has helped to bring the transportation crisis.

The building of houses to care for growth of population and emergency construction around new munitions works are halted by lack of hands. Even the shipbuilding program upon which our success in the war so largely depends is endangered by want of an adequate and appropriate supply of workers.

And the situation will no doubt go from bad to worse. The war is sure now to last at least another year, and the taking of another half million or more men from industry for military service will further deplete our labor force. The labor of supplying an increased army with munitions, clothes and food will still further tax our productive powers. As the war goes on and the brunt of the struggle passes to the United States, the demand for materials will increase disproportionately, and our industrial efforts must be inordinately increased to supply our own shortage—not to emphasize the need of our Allies,—likely to be increasingly bitter.

No wonder that panic-stricken editors have been seeking the breakdown of standards of hours of work, asking for the widespread employment of women and for industrial conscription. The production required to support our armies and navies and win the war is being deterred by the chaotic condition of the labor market, the dearth of effective man power. This is the first time of industrial expansion in which definite and universal attention has been called to the anarchic individualism of our employment system. Hitherto we have been

content merely to discuss and worry with the problems of employment in times of distress and depression. The futility of past attempts is seen in the panic of 1914, when immediate relief and not constructive change still characterized our policy. In peace times we have failed to solve our labor problem, the great task of providing comprehensive machinery for the securing and maintaining of an adequate labor supply. Now as an inevitable measure of war efficiency we face the need of grappling successfully with the problem.

This trying and complex situation will not be met by sweeping generalizations, by hurling denunciation, or calling for panaceas. It can be met alone by authentic information, temperate analysis and slow constructive effort. Where are we to get the labor to serve our industrial effort?

The problem of labor shortage admits of many solutions. For the time being, at any rate, two solutions must be ruled out. The supply can not be increased by immigration, and English experience proves that extension of hours of work does not increase, but actually decreases, production. There is another theoretical solution which may be of scant immediate practical significance—the reduction of labor need by technical improvement and introduction of automatic machinery to replace labor power appreciably. The main practical expedients at hand, then, are obviously the increased employment of women; the diversion of workers from the production of luxuries that the nation must forego in the rigors of war, and finally the adequate and complete organization of the labor market to eliminate or reduce turnover and time loss between jobs, and lessen unemployment. We must utilize the existing labor supply to the fullest possible extent in the present crisis, if we are to attain the great aims we have set for our nation.

Valuable distinctions which must be borne in mind in getting at our difficult problem, are between shortage in skilled and unskilled labor, and net shortage as contrasted with local, temporary shortage.

There was undoubtedly with the falling off of immigration in a period of industrial boom following the war an unprecedented dearth of unskilled labor in the North in steel and railroad industry and in construction work. This shortage was met by bringing or inducing to come North more than half a million negro workers from the low-priced labor market of the South. But less than five per cent. of these workers are being introduced into skilled services. Again, women have been and are now being drawn into rough, unskilled work in increasing

numbers and they are being slowly trained and directed into skilled activities. In Europe the use of women in industry has been remarkable.

A year ago, over a million new women had entered industry since the start of the war—about 985,000 replacing men. Employment of women saved England. Munition work is largely done by them. According to a recent editorial in The New Republic at Woolwich Arsenal, for instance, in August, 1914, only 125 of 10,866 workers were women. Now over a third of the 75,000 workers employed are women. In the United States there is as yet no definite information, but unofficial reports show rapid recruiting of women into industry, in munition works, railroading and other occupations formerly engaged in by men alone.

Conscription of Labor

In the unskilled groups particularly, the inability to secure an adequate labor supply is now marked, because of the casual character of the labor force of single men available. The turnover figures run above a thousand per cent. and are almost incredible. It is no wonder that the call comes for "conscription of the labor force." Yet on second thought this is but a short-cut remedy of coercion. If we understood the implications of the term we would not use it so glibly. Forced labor has never been efficient. Even organized Germany with her great war need has not proven that military control and punishment secure results from unwilling workers except in the crudest tasks and its supervision is too costly save by an army in the field; and conscription would be unfair and inexpedient except in a completely socialized nation. A return to compulsory labor even in war time might be a return to "slacking" and "sabotage" losses which have always gone along with such work. The present labor force is, in a measure, working gladly and energetically; add to its numbers by conscription and force them to work by law or threat of army service and the mutiny that agitators teach will seem to have a cause in fact. The seeds of organized revolt may soon be sowed in our midst. In any case, the young, unskilled casuals will be taken in the draft and that new experiment is difficult enough.

Rather must this unskilled labor force outside the draft age be attracted and held than coerced. It can be held, we were convinced, by a study of the negro migration this summer, only by selection of family men and provisions of living conditions on a family basis. In this regard the problem is exactly that of the skilled worker; the reduction of turnover and securing of a

stable labor force in any plant must wait upon adequate provision of decent housing facilities. But the subject of industrial or governmental housing is another story and would require separate treatment.

Skilled Labor Shortage

Is there a net shortage of skilled workers? When we hear of the labor force that the Emergency Fleet Corporation will need to create its 6,000,000 tons; now announced as 300,000 men, and the increasing shortage of the munitions plants, there seems to be a great lack. But no one knows if these men do not exist, or are merely out of touch with the new jobs. We know, indeed, that men are being now laid off in numbers by industries suffering from the war, because of lack of fuel and materials, or decreased demand for products. For instance, in Pittsburgh with a marked shortage of unskilled men, an actual surplus of mechanics and carpenters, who have drifted in perhaps from the cantonments and who need to be placed elsewhere, now exists. The war work of the nation has been curtailed because no comprehensive system of labor management has been developed.

Organization of the Labor Market

Our greatest problem, particularly in meeting the skilled labor need, is still the distribution of our labor force to the necessary industrial work, reducing part-time work, elimination waiting between jobs and the tremendous turnover of labor. This is now estimated by employment managers to average over 100 per cent. a year, through this country, and in the shipbuilding force and the unskilled negro labor group it runs over 1,000 per cent. Our present labor force because it is inefficiently handled is not rendering one half of its possible service, is not fifty per cent. efficient.

Competition has in the past been unregulated by considerations of national welfare. Industry has habitually depended upon a surplus labor force, and hiring and firing with free contract, to obtain workers. We disregarded the pathetic need of the surplus laborer; now the dire need is that of the nation and we must meet it. It is lack of mechanism for distribution of labor rather than a dearth of labor that brings the present crisis.

Labor Exchanges

We have not yet created national agencies to connect the jobless man and the manless job. The 23 state public employ-

ment bureaus have been sadly handicapped by insufficient funds and untrained personnel and have worked mostly with placing the unskilled laborer. Now the states are seeing the situation more clearly in Committees of Public Safety. Pennsylvania has set aside $25,000 of the Defense Fund for the labor-placement work of the Civilan Service and Labor Committee, and the number of offices has been increased from five to thirteen. The United States Employment Service which grew out of the work of Immigration Bureau of the Department of Labor has some 94 offices at present. The last session of Congress appropriated only $250,000, a mere fraction of the cost of an adequate system. It placed about 41,000 in August, a small per cent. of the need. For five weeks, ending July 13, the British Exchanges, 400 in number, placed 175,000. The members of the British Munitions Board on their recent visit announced the English plans to increase the number to 2,000; over ten times as many as the United States with a population twice as large.

A Federal Employment Service and the Robinson-Keating Bill

A new Employment Service has been given independent organization in the Department of Labor, in charge of a director appointed by the President. As a special emergency measure and upon official request a bill has just been introduced into Congress for federal coordination of Public Employment service throughout the country to secure maximum production in essential war industries. Congress is asked to grant the federal service a considerable appropriation. The bill extends and unifies all labor-exchange functions of the government. Centralized control and unified policy would assure efficiency; close cooperation of state bureaus in touch with demand and supply of labor is secured by national aid, "dollar for dollar" to such state and city bureaus.

Gains from National Organization

If the bill is passed, it will not only help to mobilize our labor to war strength, but will provide for the period of reconstruction and demobilization after peace, an effective method of absorbing soldiers back into industry; such regularization of industry will meet the increasing industrial needs of the future.

It may also provide the means for systematic inquiry, bringing real knowledge of the possibility of the substitution of the

labor reserve of women for that of men; the men displaced could be directed to the industries needing their service most; and the need for training the new industrial army of women would be made clear.

Analysis of the Labor Force

An efficient policy of labor distribution must be based on knowledge of the number of men engaged in trades, where they are, and the nature of their work and experience. The Bureau of Labor Statistics does not have and is not equipped to secure this information. Congress has given the Bureau but meager funds. Yet no intelligent policy of labor priority can be developed for the government by the War Industries Board Priority Committee, for instance, and followed by labor exchanges, until we have this full and detailed information about the labor supply, in the form of an index capable of practical use in finding individual workers.

The draft supplies such an index for the male labor force between twenty-one and thirty-one. But we need now a national registration of men and women between sixteen and sixty well planned and executed. This would be accomplished by a similar system, standardized for the nation; it would be simpler than the draft, as the irksome questions of dependents and liability to service would be eliminated. Such registrations, inadequately done, have already been tried by five states and, despite the crudity of the method, have proved of value. A modern filing system would convert a standardized national registration into an index of man power, to be used by exchanges, and of immeasurable value for subsidiary registrations to meet specific war and peace needs.

Employment Management in Plants

In addition to an efficient system of labor exchanges and an index of labor to utilize our labor supply to the full by distribution, there must be real employment management inside the plant. Without waiting for securing a labor index, much can be done to meet the pressing needs of distribution of labor. The Emergency Fleet Corporation has introduced modern employment methods in the shipyards. In each yard, hiring is now done by this employment manager, who has analyzed his job. Applicants are put at work for which they are best fitted. If capable of taking training they may be sent to special schools. Teachers for this standardized instruction are already

being trained at Newport News. If foremen fire men the latter report to the manager before leaving, so that if possible they may be sent to other work in the plant, or be referred to the Federal Exchange for labor service in other shipyards. The local manager is the clearing house for labor and turnover will be much reduced, as it has in the last year by the introduction of similar methods of the New York Shipbuilding, Newport News and Fore River plants. This work will be materially aided by effective government aid to housing; the need here now constitutes the largest single factor in the disorganization of the labor situation. These methods must now be extended to all essential industries, steel and munition plants and railroads, especially. It represents the framework of the new machinery for labor distribution—local managers who work through the Public Employment Service, using scientific information publicly compiled.

WHAT ARE ENZYMES?

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THE word enzyme comes from a Greek word meaning "in yeast" (*en*, in; *zyme*, leaven). Perhaps the most acceptable definition in the light of recent scientific research is to say that it is a substance showing the properties of a catalyst and produced as a result of cellular activity.

But what is a catalyst? The reader will recall his first very simple experiment in the preparation of oxygen. Here the learned instructor tells the bewildered youth that if you put a little potassium chlorate in a test tube and heat this very strongly, a gas is evolved which is later identified as oxygen. Now by merely adding a small quantity of a dirty black-looking powder, called manganese dioxide, to the potassium chlorate, the oxygen is evolved much more rapidly and at a much lower temperature. But this is not all. A careful examination at the end of the reaction shows that the manganese dioxide has not changed in any way: we have the same substance, and the same amount, at the end of the reaction as at the beginning. Many such substances are known to chemists. They all have this peculiarity: that they *accelerate* chemical reactions, and that a relatively small—at times insignificant—quantity of the catalyst suffices to bring about the chemical change.

In cells we find substances of this type, but thus far these cellular catalysts, unlike the manganese dioxide, and like proteins, have never been produced outside of the cell.

When we consider that life is possible only because of continued cellular activity, and when we bear in mind that this activity is largely the result of chemical changes brought about by these enzymes, the paramount importance of these substances becomes manifest.

Alcoholic fermentation in yeast, the souring of milk, processes of putrefaction, and various other examples of changes in organic materials with, often enough, the accompanying liberation of bubbles of gas, had long been known. The epoch-making researches of Pasteur had shown that fermentations and putrefactions were inaugurated by the presence of living organisms. Then later extracts from the saliva and the gastric

mucosa of the stomach were obtained which also had the power of bringing about chemical changes in carbohydrates and proteins. This led to the classification of ferments into those which, like yeast and certain bacteria, acted because of certain vital processes (organized ferments), and those which, like the extracts from the saliva and stomach, were presumably "nonliving unorganized substances of a chemical nature" (unorganized ferments). Kühne designated the latter "enzymes." This classification was generally accepted, and the "vitalists" held absolute sway until Emil Buchner, in 1897, overthrew the whole theory by a series of researches which, in their influence, were only second in importance to those of Pasteur in an earlier generation. One of Buchner's classical experiments consisted in grinding yeast cells with sand and infusorial earth, and then subjecting the finely pulverized material to a pressure of 300 atmospheres—a pressure far more than enough to destroy yeast, or any other cells. The liquid so obtained had all the fermentative properties of the living yeast cell. Obviously, then, the living cell could not be responsible for the fermentation. On the other hand, this experiment did suggest that cellular activity gives rise to some substance which, once produced, exerts its influence whether the cell is alive or dead. All subsequent experiments have but strengthened the conviction that cells do produce these substances, and that the chemical changes are due *not* to the living organisms, but to the *lifeless* substances (enzymes) to which these organisms give rise.

Minute in quantity, and tenaciously adhering to substances present, particularly protein, the isolation of an enzyme in the pure state has become one of the most difficult problems in physiological chemistry. Yet any elementary student in the subject finds little difficulty in performing simple experiments which convince him either of its presence or of its absence. How are they done?

The method consists essentially in making use of the so-called "specificity" of enzymes. To use Fischer's simile, just as one key fits one lock, so any one enzyme will act on only a certain type of substance. Take, for example, the enzyme found in saliva, ptyalin: it readily acts on the carbohydrate, starch, but has absolutely no action on protein. Again, take the pepsin of the stomach: this enzyme breaks down proteins, but is without result on carbohydrates. These instances may be multiplied indefinitely.

Some enzymes show their specificity to an even more

marked degree. In the yeast cell, for example, we find one, sucrase,[1] which acts only on cane sugar (sucrose); but on no other sugar or carbohydrate. A simple little experiment demonstrates this beyond question. A yeast cake is ground up very intimately with a little sand and water, and the mass filtered. A small portion of the filtrate is added to a solution of cane sugar, the mixture placed in an incubator kept at 38° C., and allowed to remain there for about 30 minutes or so. At the end of that time the mixture, if heated with Fehling's solution,[2] will yield a red-brick precipitate—a result which could not be obtained either with the cane sugar, or with the enzyme solution alone. No other carbohydrate solution—or protein, or fat solution, for that matter—can take the place of the cane sugar; our enzyme will be without effect. If we take our original yeast extract, and first heat it to, say, the boling point of water, then cool it, and from here on repeat the experiment as before, no grape sugar is obtained. If instead of heating the enzyme solution, we cool it, the action is considerably delayed.

Some of the yeast extract may be poured into an excess of alcohol, the precipitate separated by filtration, and redissolved in water. This solution will show all the properties of the yeast extract.

Evidently, then, the watery extract of yeast contains something which has the power of breaking down cane sugar. This something is exceedingly sensitive to heat, rather less so to cold, and is precipitated—together with other substances (as could be shown)—by alcohol. The last three properties are characteristic not only of sucrase, but of all enzymes to a greater or less degree. That a minute quantity of enzyme can act upon an exceedingly large quantity of substrate is also readily demonstrable. The laws of catalysis hold firm.

One other fact about enzymes is most important. Graham, as far back as 1861, found that certain substances (cane sugar, salt, etc.) in solution, when placed in a dialyzer consisting of a parchment bag, which in its turn was surrounded by water, would diffuse through the bag, whereas others (proteins, gum, starch, etc.) would not. The diffusible ones he named crystalloids, those non-diffusible, colloids. If some of our original

[1] The ending "ase" denotes enzyme.

[2] This is the well-known alkaline copper solution used by all medical men to test for sugar in the urine. The sugar in the urine is not, as might be supposed, ordinary cane sugar, but grape sugar. Fehling's solution reacts with the latter, but not with the former.

The cane sugar is split or "hydrolyzed," by the sucrase, one of the products being grape sugar.

yeast extract were placed in such a parchment bag, none of the enzyme would find its way into the surrounding layer of water. Enzymes, like the proteins, are *colloids*.

The fact that enzymes show colloidal properties, and the fact that they are invariably associated with proteins, made it seem probable that when ultimately isolated in the pure condition, they would be found to be proteins. Attempts to obtain pure enzymes have been many. The general method of procedure in almost all cases consists in first extracting with water[3] —as already explained—or submitting the mass to much pressure (Buchner), if the enzymes are "intracellular."

Having obtained a solution, the next step is often that of dialysis (Graham). Diffusible bodies, particularly inorganic substances, are thereby separated. Three of the classical investigators in this branch, Osborne, Peckelharing, and Fraenkel, have all employed this method.

Now usually comes precipitation. Some substance—alcohol, acetone, or ammonium sulphate—is added in which the enzyme is insoluble. The precipitate so obtained contains many impurities (proteins, certain carbohydrates, etc.). To purify it, it is redissolved, re-dialyzed, and reprecipitated many times. On occasion, a biological procedure, first suggested by Effront, and put into practise by Fraenkel, may be used. This consists in fermenting the impure precipitate with yeast. The carbohydrate and protein are thereby used up, but according to Fraenkel, the enzyme is not touched.

The laboriousness of such an operation may best be gathered from a specific example. Let us take an experiment from the work of Professor Sherman, of Columbia, an active investigator. Here is his method for preparing a starch-splitting enzyme from the pancreas: Mix thoroughly 20 grammes of pancreative powder—a commercial preparation—with 200 cubic centimeters of 50 per cent. alcohol at 15–20° C. [S. finds that much of the contained protein is left behind by the use of this 50 per cent. alcohol.] Allow this preparation to stand 5–10 minutes, then filter, keeping the temperature below 20° C. (This takes from 1 to 2 hours.) Pour the filtrate into 7 times its volume of a mixture of 1 part of alcohol to 4 parts ether (more protein and other impurities are here separated). Within 10–15 minutes the enzyme (including certain impurities) separates as an oily solution. Decant the supernatant liquid. Dissolve the precipitate in the smallest amount of pure water at a temperature of 10–15 degrees Centigrade and

[3] Often containing alcohol, toluene, or chloroform (as preservatives).

reprecipitate at once by pouring into 5 volumes of absolute alcohol. Allow it to settle, keeping temperature low; filter, dissolve in 200–250 cubic centimeters of 50 per cent. alcohol containing 5 grammes of maltose. Pour the solution into a collodion sack of 500 cubic centimeters capacity, and dialyze against 2,000 cubic centimeters of 50 per cent. alcohol at not above 20° C. and preferably not below 15° C. Replace dialyzate twice: after 15 hours and a second period of 8–9 hours with fresh 50 per cent. alcohol. Continue dialysis 40–42 hours. Filter. Pour clear filtrate into an equal volume of a mixture of alcohol and ether (equal parts). Filter in the cold, and place the precipitate in a vacuum desiccator.[4] The powder obtained is so active that it can digest 20,000 times its own weight of starch. And still we are not at all certain that this is an enzyme uncontaminated with foreign bodies!

Of the three or four representative workers in attempts to isolate a pure enzyme, the substances obtained by Professor Sherman and Dr. Osborne (of the Connecticut experiment station) showed decided protein characteristics; whereas the two German investigators, Lentner and Fraenkel, both agree in proclaiming their products as carbohydrate in nature. How near or how far from the truth is either group? To begin with, no proof that any of these products is 100 per cent. pure has been advanced, and the chemist through bitter experience knows the danger in discussing the composition of impure substances. Another fact to be kept in mind is that, often enough, the purer the enzyme, the less active does it become. In several of these cases it has been shown that a loss in activity goes hand in hand with a proportional loss in the phosphoric acid content of the substance. This gives rise to the possibility—expounded further on—that the enzyme is not a chemical individual, but consists of at least two substances: (*a*) a something which has the power of acting only when activated—in this instance—by (*b*) phosphoric acid. And yet, if arguing by analogy is at all permissible, it may be maintained that since all the inorganic catalysts are distinct chemical individuals, why not enzymes?

Of course, all this does not at all exclude the possibility that different enzymes may have different structures and the conflicting results of investigators may be due to this fact. Some of the men worked on amylases (starch-splitting enzymes), others on lipases (fat-splitting), others still on proteases (protein-splitting). Why assume that such diverse substances

[4] A vessel (containing a hygroscopic substance to take up moisture) from which the air has been exhausted.

should all have the identical composition? It may be, as Professor Armstrong has suggested, that the enzyme in constitution is similar to the substance on which it acts.

Extremely suggestive as the basis for much present-day activity has been the work of Professor Gabriel Bertrand, of the Sorbonne, Paris. Most of this has been on laccase, an oxidizing enzyme first found in the milky latex of the tree *Rhus vernicifera*, and since then in many plants. The production of the beautiful Japanese lacquer from the latex of *Rhus vernicifera* was shown to be due to the activation of the atmospheric oxygen by the laccase (hence its name). Bertrand was able to prove that the activity of the laccase was connected with the manganese present, for by repeated precipitation with alcohol, he divided his laccase preparations into three fractions of different manganese content, each with an activity distinctly proportional to the amount of manganese present. As further proof of the importance of this manganese, he was able to show that a minute addition of a salt of manganese (manganese sulphate) increased the activity of the laccase, whereas other metals had no such effect. This led him to the dual conception of an enzyme, also advocated by Armstrong: one of the constituents is capable of producing, to a slight degree, on its own account, the chemical reaction associated with the particular enzyme in question, but requires its activity to be augmented by the presence of another substance—inactive in itself—before its action becomes appreciable. The former may consist of acid, alkali, calcium or magnesium salt, etc. The latter component is more complex, usually protein-like (egg-white, for example), and colloidal.

Bertrand's views—perhaps, also, Fischer's colossal work on the synthesis of proteins from amino acids—has led the school of enzyme chemistry to shift its ground considerably. Why these laborious, and always futile attempts to isolate a pure enzyme from the cell? Why not attempt to synthesize one from simple inorganic and organic materials? Trillat, in 1904, prepared a mixture of traces of manganese chloride and egg albumen which showed the reaction of laccase and other oxidases (oxidizing enzymes): it blued guaiacum, its action was prevented by heat and acid, and it could be precipitated by alcohol, and redissolved in water without losing its oxidizing powers—characteristic properties of *all* enzymes. Wolf with his colloidal iron compounds, and Euler and Bolin with their calcium salts of organic acids (citric, malic, etc.), and many others, have produced strong evidence in favor of the view that many of the

enzymes, at least many of the so-called oxidases, are relatively simple substances.

Along somewhat modified lines is the work of Panzer, who claims that various carbohydrates show distinct diastatic (carbohydrate-splitting) activity when heated with hydrochloric acid gas, and then ammonia; and that of Woker, whose findings, at present rather disputed, would tend to the belief that formaldehyde (the "formalin" of commerce) may, under certain conditions, act in place of diastase in hydrolyzing starch.

Some very far-reaching possibilities are suggested by the studies on the lipases (fat-splitting enzymes) of castor and soya beans by Dr. Falk, of the Harriman Research Laboratory. Every worker in the field is aware how very easily enzymes are inactivated or destroyed by heat or the presence of relatively small quantities of certain foreign bodies, such as acids and bases. The inactivation of the lipases of the beans could be brought about not only by these means, but also by neutral salts, alcohols, acetone, etc. Dr. Falk conceived the idea that this inactivation was due to an internal rearrangement of certain of the atoms in the molecule of the enzyme. Many cases of such tautomeric changes—of rearrangement within the molecule—are known to organic chemists, and are often stimulated by the action of mild chemical agents. Dr. Falk's hypothesis is to the effect that the grouping involved is to be found in all proteins, and hence, probably, in enzymes. If inactivation means the rearrangement of a group from configuration 1 to that of 2, activation, or change from 2 back to 1, may be brought about by the action of dilute alkali—often used to bring about these changes in configuration. Actual experiments on the action of alkali on proteins (themselves quite inactive) have endowed these substances with fat-splitting power.

Whilst, therefore, we are far from a comprehensive knowledge of the chemical configuration of an enzyme, studies on the production of artificial enzymes, and on the possible rearrangements of certain groups within the molecule, may throw much light on a very perplexing problem.

THE GIRASOLE OR JERUSALEM ARTICHOKE, A NEGLECTED SOURCE OF FOOD

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THE sunflowers, genus *Helianthus*, are native only in the Western Hemisphere. Botanists recognize about 70 valid species in America north of Mexico; but Mr. S. Alexander, who minutely studied the sunflowers of Michigan, recognized some hundreds of forms, which he regarded as species. These have not yet been described. About a dozen species are known from Mexico, one is recorded from Guatemala, and about 25 come from South America, nearly all from the mountains of Chile and Peru. The South American sunflowers need investigation, but the materials for a revision do not exist in American herbaria. Only two or three of those represented in the herbarium of the New York Botanical Garden appear to be genuine *Helianthus*, but one collected by R. Pearce at an altitude of 8,000 feet in Bolivia, and also collected in Bolivia by Rusby, is quite of the type of the North American perennial species.

It is in the northeastern United States and adjacent Canada that species of *Helianthus* develop edible tubers. Mr. S. Alexander, who paid particular attention to the root-system, distinguished a great group of sunflowers which possess no permanent crown, but reproduce annually by seeds and earth-branches. These he called "binatal annuals," although they are ordinarily classed as perennials. They are of course perennial in the same sense as the potato. A key based on Mr. Alexander's manuscript subdivides this group as follows:

Leaves petioled.
  Petioles winged.
    Species with cord-like migrators.....*Helianthus* sp.
    Division *Tuberosæ* (Alexander), with distal ends of migrators bearing tubers.....*H. tuberosus* and allies.
  Petioles not winged.....*Helianthus* sp.
Leaves not petioled.
    H. doronicoides, H. mollis, H. ciliaris, H. radula, H. cinereus.

The last is a very miscellaneous lot, the species not closely related. *Helianthus tuberosus* is the Jerusalem artichoke. The Tuberosæ, according to Mr. Alexander, include *H. tuberosus* and its variety *subcanescens* of Gray, and "at least 100 or more

well-marked species," all of which are undescribed. These latter would probably not be considered species by most botanists, but their comparatively slight differences may prove very important in the development of horticultural types.

In both the potato and the Jerusalem artichoke the tubers arise from underground stems, the earth-branches of Alexander. As has been pointed out by Reed (1910), the tubers of the potato are terminal, whereas those of the *Helianthus* are formed laterally as well, or the earth-branch itself may swell up and become a tuber. Consequently the *Helianthus* bears a mass of tubers close to the crown, though others may be more widely separated in the soil. It results from this arrangement that the tubers are very easy to harvest, and the tuber-bearing region occupies a surprisingly small space, considering the quantity of the tubers.

Helianthus tuberosus is not the only member of the genus which has been used as a source of edible tubers. *H. subtuberosus*, the so-called Indian potato of Michigan and Minnesota to Saskatchewan and Montana, has thick fleshy edible tubers. It was used by the Assiniboines. *H. doronicoides*, native from Ohio to Missouri and Arkansas, is used as food in Europe. Vilmorin of Paris offers it for sale, remarking that "les rhizomes de cette plante, produits en abondance, peuvent être consommeés à la facon de salsifs." It has been found by von Héries-Tóth and von Osztrovsky (1911) that the tubers of *H. doronicoides* are good raw material for the production of alcohol, while the refuse contains considerable amounts of fat and protein, and can be fed to stock.

Helianthus tuberosus, as a source of food, was well known to the natives of America long before the advent of the white man. Dr. V. Havard (1895), in an account of the food-plants of the North American Indians, says:

> The first place belongs to the Jerusalem artichoke (*Helianthus tuberosus* L.). It produces many edible tubers, sometimes two inches in diameter, in our day mostly used for the feeding of cattle, horses and pigs, but which were precious to the Indians on account of their hardiness and prolificacy, retaining possession of the soil for many years. These tubers were mentioned by Champlain in 1603, and brought to France by Lescarbot, who, in 1612, describes them as being "as big as small turnips, excellent to eat, with the taste of artichoke but more agreeable, and multiplying in a wonderful way." As the plant is native of the valleys of the Ohio and Mississippi, and does not reach any part of Canada, it is evident that the Canadian and New England Indians who planted it must have obtained it from the tribes further south and west, so that we may infer a rather large area of cultivation. The Jerusalem artichoke is, so far, the only contribution of North America, exclusive of Mexico, to the vege-

table garden of the world, and it can be said to be an aboriginal contribution. Strange to note, it is now much more cultivated in the Old World than on this continent.[1]

The tubers appear to have been highly appreciated in Europe from the first. The plant was grown in the Farnese Garden at Rome, and was distributed thence under the name Girasóle Articiocco, or sunflower artichoke. It was early reputed, by some mistake, to be a native of Brazil, and this error crops up in various compilations, down to recent times. Venner (1620) stated that the tubers were usually eaten with butter, vinegar and pepper. Parkinson (1629) noted that they were very commonly offered for sale in London.

The name artichoke is supposed to be derived from the Spanish-Arabic alkharshof, applied to the thistle-like plant *Cynara scolymus*, a native of the Old World. This is the true artichoke, and the edible part is the flower-head, particularly the thickened involucral bracts. Thus the true artichoke and the Jerusalem artichoke have little in common, the plants being entirely different in appearance, and furnishing quite different parts as food. The name artichoke appears to have been given to the *Helianthus* solely on account of the more or less similar flavor, while "Jerusalem" is an English corruption of the Italian "Girasole," or sunflower. Thus the designation "Jerusalem artichoke" is as misleading as "guinea pig," or "Christian Science."

The confusion resulting from the name necessitates considerable caution in using published records. Thus in Edw. Smith's well-known book on foods (Internat. Science Series), which has gone through ten editions, the two plants are discussed as if they were varieties of one thing, and most of the statements are made as if equally applicable to both. C. E. Quinn (1908), in a Farmers' Bulletin on forage crops for hogs, discusses the *Helianthus* under the name artichoke, with no indication of the fact that it is not the true plant of that name. It is quite common to find the name artichoke thus applied indiscriminately, and unless one knows the difference between the plants, and can find the characteristics mentioned in the text, it is difficult to understand what is intended. The French have a distinctive name, *Topinambour*. This is rather long and difficult to pronounce, but the Italian *Girasole* is short and simple, and is the proper form of the absurd "Jerusalem." We may therefore perhaps use it for our *Helianthus*, though it is open to the objection that to an Italian it means a sunflower, and probably suggests the annual species of gardens rather

[1] *Bull. Torrey Bot. Club*, March, 1895.

than any other. Britton and Brown give two English designations, earth apple and Canada potato. The first is objectionable, since pomme-de-terre is French for a potato; while the second is doubly misleading, the plant being neither a potato nor originally specially characteristic of Canada; though to-day it is said to occur from Nova Scotia and Ontario to Manitoba. On the whole, then, Girasole seems the least objectionable term. It is a singular fact, as Havard remarked, that a plant so highly esteemed by the American aborigines, and for three hundred years used in Europe, should find so little favor to-day in the land of its origin. The literature indicates that it is probably even less used now than when Havard wrote, some twenty years ago. Our experience at Boulder having indicated the astonishing size of the crop, and the value of the tubers as human food, we could not understand the apparent neglect. Wishing to ascertain the exact facts, I wrote to a number of experiment stations and to Washington, and am exceedingly indebted to those addressed for their prompt and courteous replies. The following will suffice to show the prevalent opinion:

U. S. Department of Agriculture. As to the possible usefulness of Jerusalem artichoke as an emergency food, all that you say in regard to its productiveness is thoroughly justified. . . . A new vegetable at best is adopted very slowly . . . it seems to me rather an impressive fact that the plant has not made its way in the United States, although it is undoubtedly a native of this country and has been with us during our whole vegetable gardening history. Apparently there must be some lack of appreciation of its flavor or some difficulty in its production, storing or cooking which has served finally to discourage every enthusiastic advocate who has started to preach its values in the past. I know there must have been many such advocates, and the fact that their labors so far have apparently accomplished so little is to me rather discouraging for a new attempt. (D. N. Shoemaker.) Reference is also made to the difficulty of preparing the irregular tubers for the table. Dr. L. C. Corbett, writing to the U. S. Food Administration (the letter kindly transmitted by Professor V. L. Kellogg), adds another objection—that it would be difficult at present to secure enough seed (*i. e.*, tubers) to plant any considerable acreage. (It would of course be easy by planting this year, to secure plenty for the year following.)

Arizona. We have tried artichokes down at the Yuma Garden; finding, I believe, that they were very badly infested by a lace wing bug of some sort, which spread from them to other plants, including sweet potatoes. We regarded them, therefore, undesirable as a crop. (R. H. Forbes.)

Arkansas. Bulletin 31, a number of years ago, gave details of experiments and analyses. At Newport the yield was 453.75 bushels to the acre; at Fayetteville 612 bushels. The tubers were fed to hogs. There are no recent developments.

Colorado. I do not think that any of our station men are really doing any experimental work with the Jerusalem artichoke. On last Sunday I was in Dean Johnson's garden, where he had planted a few artichokes, and was astonished at the very large yield. One plant had fully

a peck of tubers. Artichokes are quite often planted as food for hogs, which do their own harvesting. (C. P. Gillette.) Colorado Exper. Station Bull. 146, on raising hogs in Colorado, and Bull. 199, on Vegetable Growing in Colorado, make no mention of the Jerusalem artichoke.

Connecticut. It is grown occasionally in gardens in Connecticut, but to my knowledge no one has grown it as a crop. (E. H. Jenkins.)

Illinois. This institution has done no work on the raising of Jerusalem artichokes as a crop. (E. Davenport.) We have so many things which seem to be much more important, that we will have to confine our attention to such crops. (W. L. Burlison.)

Massachusetts. Bulletin 47 contains analyses. They were never raised to any extent.

Michigan. This old, well-known plant has been grown very little to my knowledge in this state. We have not tried out any variety of it. . . . Where I have seen it grow, it did not yield sufficiently heavy to give a very large return per acre. (C. W. Waid.)

Missouri. No information available.

Nebraska. We have had no experience with artichokes of any kind or variety. A few have been grown in some sections of the state, but they are grown entirely as hog feed, the hogs being allowed to root them out. (W. W. Burr.)

South Dakota. Jerusalem artichoke was cultivated to some extent years ago for hogs, but I do not know why the matter was not carried on further. I believe the plant could be greatly improved as a crop for feeding to swine. It certainly can be raised cheaply, and the swine can do their own harvesting. (N. E. Hansen.)

Washington State. Our Western Washington Experiment Station has done some work with the artichoke, but we have never considered it a plant of great merit, and have therefore done very little to encourage its production. (Geo. Severance.) Bull. 7, however, gives some remarkable results, cited below.

Wisconsin. We have done nothing with its culture here. It is grown to some extent as a plant upon which to pasture hogs, but I know of no particular work which has been done with it. (J. G. Moore.)

The above statements might be sufficient to discourage any one, but there is another side to the question, and it is worth while to review the principal facts about the plant as a crop, and as a source of food for man and beast.

At Boulder, Colorado, in 1917, we planted the white variety in a field which had been for two years in *Helianthus annuus*. No fertilizer was used, but the soil was exceptionally good for the locality. The tubers were planted three feet apart in the rows, and the rows were two feet apart, each plant thus occupying six square feet. The yield was found to be at the rate of 9.66 tons to the acre. This greatly exceeds the average yield of potatoes. The most astonishing yield is reported from Western Washington by W. H. Lawrence (Bull. 7, Wash. Exper. Sta., 1912). Of the red variety, "335 lbs. of tubers were dug from an area of 360 square feet—at the rate of 20.26 tons per acre." The white variety was even more prolific; "on upland

clay near Alequa 2,015 square feet produced an estimated yield of 38.9 tons per acre." (In the Experiment Station Record, XXVIII., p. 531, it is erroneously stated that this yield was in sandy soil.) No wonder the author added:

> Jerusalem artichokes have not been given the attention they should receive. From the experiments it is evident that a large tonnage per acre can be grown of either the white or red variety, and that large yields may be obtained at a low cost.

Yet to-day, in Washington State, the experiment station authorities have lost interest, following the general trend throughout the country. M. Rau (1914) compared the Jerusalem artichoke with the potato on the basis of German experience, and decided that the former was superior as a forage crop, "as it requires less labor to plant and cultivate, yields more heavily in tubers and straw, is of higher food-value, and the tubers have a greater frost resistance" (*Exp. Sta. Record*, XXXI., p. 433). Analyses are given, showing the difference in favor of the girasole.[1] Sutton and Sons of England report that a gardener (J. Barker) planted six pounds of tubers and got 18 stone of "splendid tubers, pure white, with excellent flavor." The Massachusetts Station Annual Report for 1892 records a yield of 8.5 tons to the acre. The Encyclopedia Americana states that the usual yield is 200 to 500 bushels to the acre, but 1,000 bushels are sometimes obtained. The average yield of potatoes per acre in the United States is said to be 84.5 bushels, but Maine, Montana and Nevada average 150–163 bushels.

The girasole can not become a competitor of the potato in such regions as the mountains of Colorado, but it thrives along the foothills and on the plains. S. M. Tracy, in Farmers' Bull. 509 (1912), dealing with forage crops for the cotton region, describes it as a valuable grazing crop for hogs in the northern and central parts of the cotton region, but states that it yields less heavily and is less desirable farther south. He adds that it yields much more heavily than Irish potatoes, and is worth fully as much for feed.

> They are strictly a winter feed, not being well matured until December. From that time on until March they furnish perhaps the least expensive roots grown for hog feed.

Thus, taking the country over, the potato is best adapted to the northern and upland regions, the sweet potato to the south, and the girasole occupies more especially the great intermediate region, as a promising source of tubers. Although the girasole

[1] In Experiment Station Record, XXXI, these figures are accidentally reversed, as I learn from Dr. E. W. Allen.

is apparently at a disadvantage southward, it can be grown under an astonishing variety of conditions, considering its rather restricted original habitat. Piper (1911) lists it among the crops grown in the Philippine Islands, and it is grown in South Africa. A special variety is said to be grown in China and Japan. Dr. L. H. Bailey writes me that he saw it freely displayed for sale in China during the past year. C. H. Shinn reported that in California it grew well on alkali soils, where legumes were not successful.

Under cultivation in Europe, the plant has produced several varieties. Vilmorin (1913) lists the following: (1) *Ordinaire.* (2) *Patate,* with yellow tubers. (3) *Blanc amélioré,* with round white tubers. (4) *Piriforme,* with red tubers, flesh sugary. (5) *Rose,* with oblong tubers, rich in sugar. The last three were introduced by Vilmorin. Sutton, of England (1917), lists *White, Rose* and *Purple,* the last being described as "the old variety," presumably Vilmorin's "ordinaire." The white and rose are described as improved forms introduced by the Sutton firm. Much work in the development of varieties is undoubtedly ahead of us; it may be safely assumed that modern methods of breeding, with more attention to the particular characters desired, will in time greatly improve the plant and give us sorts adapted to special purposes, as in the case of the sugar beet.

Analyses suggest that the food-value is about the same as that of the potato, but, as the carbohydrates are different, further investigation is desirable.[2] Mr. Russell N. Loomis, of the University of Colorado, has kindly analyzed the white variety grown in Boulder, with the following results from two samples, the figures representing percentages:

	Sample 1	Sample 2
Moisture	83.09	83.89
Ash	0.77	0.77
Protein	1.41	1.50
Ether Extract	0.35	0.55
Carbohydrates (direct method)	11.60	10.44
	97.22	96.45
Crude fiber (included in carbohydrates)	0.76	0.69
Carbohydrates (by difference)	14.38	13.29
Calculated on Water-Free Basis		
Ash	4.55	4.57
Proteins	8.31	9.68
Ether Extract	2.06	3.14
Carbohydrates (direct method)	68.53	64.80
Crude fiber	4.48	4.22
Carbohydrates (by difference)	85.03	82.49

[2] I am greatly indebted to my colleague, Dr. J. B. Ekeley, for advice concerning the chemistry of the plant.

Comparing three German analyses and one in Mass. Bull. 47, we find general agreement. Our water-content is highest, the other records showing about 71.5 to 81 per cent. This may be due, at least in part, to our sample being analyzed soon after digging. There is a marked discrepancy in the ether extract, other analyses giving (as fat) .70 to 1.30 per cent. of dry weight only. My colleague, Dr. Ramaley, remarks that our ether extract doubtless includes the resin, of which there is probably a considerable amount. It is not quite clear, however, that this is excluded from the other analyses, which seem to have been made in the same manner. The protein content is evidently variable, different records showing a range of from 6.20 to 12.82 per cent. of dry weight. The same variability is found in the potato, which showed a range from 6.52 to 17.56 in samples from eight different stations in Germany. The usual analyses give the carbohydrates as "nitrogen-free extract," obtained by deducting the water, ash, protein and ether extract from 100. This is evidently very inexact, as direct analysis gives a much lower figure, as will be seen above. Our figures agree with other analyses, whether made by the one method (Behrend) or the other (Strohmer and Stift, Rau, Mass. Bull. 47).

The whole subject is complicated by the peculiar nature of the carbohydrates in the girasole. The taste is sweet, and there is evidently free sugar. The tubers of Compositæ, as a result of photosynthesis, store up inulin, in place of starch. Inulin has the composition $(C_6H_{10}O_5)_n + H_2O$, and occurs, not in granules, but in solution in the sap. It may be separated out as a white powder, and is slightly soluble in cold and readily soluble in hot water. The saliva does not convert it into sugar, but it is presumably made digestible by being changed into levulose in the stomach by the acid gastric juice. Experiments reported by Sandmeyer (1895), Mendel and Nakaseko and Mendel and Mitchell indicate that inulin may have only moderate value as food; though "inulin" bread and biscuit have been put upon the market, and are supposed to be good for invalids. E. H. S. Bailey[3] states that the girasole tubers "contain 14.7 per cent. of sugar and no starch, but they contain considerable inulin, a substance isomeric with starch." Tanret,[4] who appears to have made the most exact analysis, found two other carbohydrates in the tubers, *helianthenin*, $12C_6H_{10}O_5 + 3H_2O$, and *synanthrin*, $8C_6H_{10}O_5 + H_2O$. He also stated that the levulin or synanthrose reported by previous authors is a mixture of saccharose (cane sugar) and synanthrin.

[3] "The Source, Chemistry and Use of Food Products," 1916.

[4] *Compt. rend.*, 1893.

Further investigations may show that the tubers can be used in the manufacture of special products. In Europe they are utilized in the manufacture of alcohol. Edw. Smith notes that 55.9 per cent. of the salts in the tubers is potash, and cultural experiments agree in indicating the value of potash salts as a fertilizer for the crop. Behrend indicates the presence of 3.88 to 6.47 per cent. of dry weight of pentosans, a class of insoluble carbohydrates.

The use of the tubers in feeding stock, particularly hogs, has been referred to above. C. E. Quinn, Farmers' Bulletin 331, states that the girasole "is superior to the common beets and turnips for hogs, and about equal to potatoes, and richer in protein than sweet potatoes." It should not be fed pure, but as part of a mixed ration. S. M. Tracy states that three bushels of tubers fed with one bushel of corn to hogs in the winter are fully equivalent to two bushels of corn, and the fresh feed which the tubers give keeps the animals in much better health than when fed on corn alone. At the Agricultural High School in Berlin the dried leaves and stalks of the girasole were fed to sheep and cows, and found about equal in nutritive value to good meadow hay. It was found advisable to use it as part of a mixed diet. Since the green parts of the plant are very large, there is here another important source of profit. The young plants are sometimes used as food for cattle. Magen reports that peasants in the south of France are in the habit of feeding the tubers to work horses, and get good results. In an experiment they were fed with crushed grain and chopped hay, and no unfavorable results were noted. The ration was found to be very economical, "both on account of the small value of the land on which the artichokes are grown and the ease with which the plant may be cultivated." Various other experiments give essentially similar results, and need not be described.[5]

Girasole tubers can be used as a boiled vegetable, as salad, or in soup. We have found them excellent food, and while the taste often strikes people as peculiar at first, it is easy to acquire a liking for them. Some prefer them to other vegetables. The tubers may be left in the ground during the winter, and dug as required. They are not injured, when thus left out, by the frost. If they are stored, they should be put in pits, with a covering of straw and earth. In preparing them for the table, the irregularity of the tubers is a disadvantage, making them hard to peel. It may be said, however, that the thin skins may

[5] In looking up references the volumes of the Experiment Station Record (U. S. Dept. Agriculture) are invaluable.

be eaten with the rest, and are not objectionable except from the standpoint of appearances. The cook-books consulted give very little information, but Mrs. Cockerell supplies me with the following notes, based on her experience. The tubers have a delicious aroma (due to essential oil) when cooking, and this should be preserved as far as possible by keeping them covered. They should be *put in boiling water*, a few tubers at a time, so as not to lower the temperature; steaming would probably be still better, reducing the loss of soluble contents. The boiling should continue 15–20 minutes (possibly less at sea-level), when the skin is easily removed. At this stage the following recipes may be employed, but in the case of the salad (No. 2) the cooking should last a little longer.

1. Soup may be made with the addition of celery tops rubbed through a colander, with milk or stock or cream added.
2. The cooked tubers sliced with egg or celery or endive, served with French dressing or mayonnaise, make a delicious salad.
3. Slice the boiled or steamed tubers, cover with milk, use salt and pepper to taste, cover with bread crumbs, and then bake for an hour. Grated cheese may be added to this dish.
4. Slice boiled tubers and fry with steak or chops.
5. Slice boiled tubers, mash, add cream, salt and pepper; or cream by adding sliced tubers to rich white sauce, and serve with toast.

It appears that we have in the girasole a plant which produces enormously, and is equally valuable as food for man and beast. In addition to its other merits, we have found it remarkably free from pests; though in Europe there is quite a long list of insects attacking it, many of them primarily infesting the burdock (*Arctium*). It seems impossible to avoid the conclusion that the cultivation of this plant, especially perhaps in small gardens, may add very considerably to the food-resources of the country, at a time when such increase is more than desirable. The greatest obstacles seem to be prejudice and lack of knowledge. In this, perhaps, as in so many other matters connected with the war, our success must depend very largely on our ability to respond to needs and rapidly adjust ourselves to circumstances.

THE MATHEMATICAL PRINCIPLES OF PICTORIAL REPRESENTATION

By Professor ARNOLD EMCH

UNIVERSITY OF ILLINOIS

THE object of artists in painting pictures, in making drawings and designs, in creating works of plastic art and sculpture, is to represent a landscape with the moods of nature, human and other living beings in their association with historic and social events, to portray and sculpture single figures and groups of figures of importance in the cultural development of a people; or merely to depict incidents of human interest in everyday life. The purpose of decorative art is embellishment and the breaking of the monotony of blank surfaces where purely utilitarian considerations do not interfere or make decoration desirable. Contrary to popular opinion that fine arts are or should be concerned with the representation of the beautiful only, they sometimes intend to create a certain impression, or to influence public opinion for a certain purpose which is moral rather than specifically beautiful. By his incomparable battle-scenes the great Russian painter Wereschtschagin, who went down with the *Petropawlowsk* near Port Arthur during the Russian-Japanese war, for example, wanted to impress the people with the horrors of war.

The methods and styles by which artists accomplish their purpose are of such a great variety that only a complete history of fine arts could convey an idea of what has been accomplished in this ideal endeavor of the human mind.

In sculpture the form of the represented model is mostly similar, if not identical, with that of the true object, while in painting a plane surface must serve as a base of representation, so that, in general, there is no geometrical similitude between the external forms and their plane pictures. The same is true of relief-modelling in which the relation between the plastic and the original figure in space is that of a certain variable scale. The laws which govern these changes in the correspondence of forms are expressed by the technical term collineation, or rather by a particular kind of collineation, called perspective. We shall be concerned with this alone, *i. e.*, with the geometrical laws which connect the original form with its

pictorial representation. Other elements of depiction, like color, shades and shadows, aerial perspective, and other effectives, lie beyond the scope of this essay. I shall first explain the principles upon which artistic perspective is based. These are so simple that any person with elementary geometrical knowledge is able to understand them. A certain minimum of theoretical considerations of this kind is necessary for the comprehension of the critical and historical remarks on the application of perspective in painting during various historic periods.

The fundamental idea of representation, or depiction, is contained in the principle of correspondence between the elements of space, *i. e.*, points, lines, and planes of the object and the elements of the figure which is supposed to represent the same. This figure we shall simply call the perspective (relief) of the object. This is merely a special concrete case of the theory of correspondences, a theory which is of the greatest importance in many lines of modern mathematical research.

In Fig. 1, let p' be a fixed plane, usually in a vertical posi-

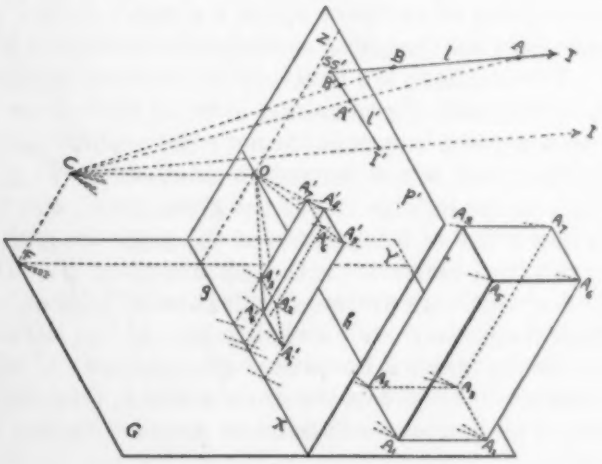


FIG. 1.

tion, and C a fixed point in space, not located in p', called picture-plane. The point C is called center of perspective and takes the place of the eye of the observer. We may think of p' as the film of a camera, or as the plane of the canvas upon which the picture is to be painted. To obtain the perspective of any point A in space, join A to C. The intersection A' of AC with p' is then the perspective of A. Thus, to every point in space corresponds a point in p'. To a point P which lies in

p' itself corresponds the point itself, *i. e.*, P' coincides with P. A straight line, or simply a line l is determined by two points, say A and B, so that its perspective is obtained as the line l' joining the perspectives A' and B' of A and B. The perspective l' of l is also obtained as the intersection of the plane passing through C and l with p'. A line, like CA, is called the projecting ray of A. When a point I moves on a line l beyond any finite region, then the projecting ray CI becomes parallel to l, and the perspective of I, *i. e.*, the intersection I' of CI with p', is called vanishing point of the line l. If S is the point where l pierces the plane p', then S' coincides with S, so that l' may also be obtained as the line which joins S' and I'. From the definition of the vanishing point of a line it follows that parallel lines in space have the same vanishing point, so that the perspectives of parallel lines all converge towards the same point, as is well known. The improper position of the point I on l beyond any finite point of l is in projective geometry defined as the infinite point of l. It is likewise possible to assume without meeting contradictions that the non-finite region of a plane is a straight line, that of ordinary space a plane. In this manner all statements in the foregoing correspondence become perfectly general. Parallel lines are now lines through an infinite point, to which corresponds the vanishing point of those lines. Lines parallel to a given plane pass through the infinite line of this plane, so that their vanishing points lie on a line in p', which corresponds to the infinite line of the given plane, and which is obtained as the line of intersection of the plane through C, parallel to the given plane, with the picture-plane p'. The only parallel lines which are projected into parallel lines are parallel lines which themselves are parallel to p'. If the picture-plane stands vertically upon a horizontal ground-plane G which intersects the picture-plane in the ground line g, then the vanishing points of all horizontal lines lie on a vanishing line h called "horizon."

In the terminology of artistic perspective these results may be stated as follows:

1. Corresponding points of the object and of its perspective lie on rays through the center.

2. Corresponding lines meet in points of the picture-plane. The perspective of a line through the center is the point of intersection of the line with the picture-plane.

3. Parallel lines have the same vanishing point through which their perspectives pass.

4. The vanishing points of lines parallel to the same plane lie on the same line.

5. The vanishing points of horizontal lines lie on the horizon.

6. Parallel lines parallel to the picture-plane are projected into parallel lines.

7. Vertical lines are projected into vertical lines.

8. The point of intersection of two lines is projected into the point of intersection of the perspectives of those lines.

9. Plane figures parallel to the picture-plane are projected into similar figures.

10. The diagonals of an ordinary quadrangle, which is the perspective of a rectangle (square), intersect in a point which is the perspective of the center of the rectangle (square).

11. The vanishing point of lines perpendicular to the picture-plane is called the eye-point of the perspective. It is also the foot-point of the perpendicular from the center to the picture-plane.

12. The vanishing points of two perpendicular lines lie on a semicircle through C over the segment between the vanishing points as a diameter.[1]

These rules, which might be increased, are sufficient to test the correctness of the perspective of a painting.

In Fig. 1, the eye-point is denoted by O. The rectangular prism $A_1A_2A_3A_4A_5A_6A_7A_8$ is placed upon the ground-plane G and with two faces $A_1A_5A_8A_4$ and $A_2A_6A_7A_3$ parallel to the picture-plane p'. Accordingly, $A_1'A_4'$, $A_5'A_8'$, $A_2'A_3'$, $A_6'A_7'$, are parallel to g; $A_1'A_5'$, $A_2'A_6'$, $A_3'A_7'$, $A_4'A_8'$ are vertical and the rest of the edges in the perspective, $A_1'A_2'$, $A_4'A_3'$, $A_5'A_6'$, $A_8'A_7'$, prolonged, pass through O on the horizon h.

Fig. 2 shows the application of the principles of perspective to landscape drawing. The perspectives of parallel horizontal lines, when produced, meet in some point of the horizon h, while vertical lines appear as vertical lines. In the landscape the background is formed by gently rolling hills. The horizon will therefore be slightly below the crest of the hills. Also the ruts

[1] For those readers who are familiar with the elements of analytic geometry, the analytic form of the perspective may be established as follows: Let G be the xy-plane, p' the xz-plane, and the plane through C perpendicular to p' and G the yz-plane, and the space in which the prism stands, the octant in which all coordinates are positive. Then when $FC = e$, $CO = b$, the coordinates x, y, z of a point A and the coordinates x', z' of the corresponding point A' are related by the formulas

$$x' = \frac{bx}{y + b}, \qquad z' = \frac{cy + bz}{y + b}.$$

of the level wagon road, which run along more or less parallel lines, when extended will meet in a point in or near the horizon. Notice also the proper perspective reduction of the scale of distant buildings and trees.

In a similar manner we may establish the geometrical principles of theatrical and relief perspective. Such a correspondence between the elements of the object and those of the

FIG. 2.

relief is technically known as a perspective collineation of space; and is determined when the center C, the plane of perspective (axial plane) s, and two corresponding points A and A' on a ray through C are given. If any other point B is given, the corresponding point B' is found by prolonging the line joining A and B to the intersection S with the axial plane s, Fig. 3. Then, join S to A', and find the intersection B' of SA' with CB prolonged, if necessary. B' is the required point. Consider next the indefinitely extended lines l through A and B, and l' through A' and B'. The infinite point I of l' is projected into a point I' of l'. Conversely, there is a point J on l whose perspective J' is the infinite point of l'. In order to shorten the theoretical discussion it is sufficient for our purpose to state that if the points I' and J are constructed for every pair of corresponding lines l and l', it is found that all points I' lie in a plane q', all points J in a plane r, both of which are parallel to the axial plane s. Again we may set up a number of rules:

1. Corresponding points lie on rays through the center C.
2. Corresponding lines meet in points of the axial plane s.

3. The perspectives (reliefs) of parallel lines meet in a point, those of parallel planes in a line of the vanishing plane q'.

4. The vanishing points of horizontal lines lie on the horizon h, which is in q'.

5. When the axial plane s (hence also q' and r) stands vertically on a ground-plane G, cutting the latter in the ground-line g, the horizon is parallel to g, and to vertical lines correspond vertical lines.

6. Corresponding planes meet in a line of s.

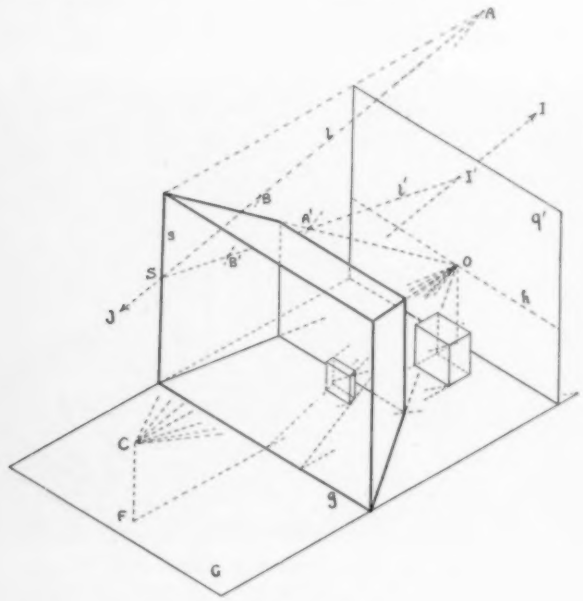


FIG. 3.

7. To planes parallel to s correspond planes parallel to s.

8. To lines perpendicular to s correspond lines passing through the so-called eye-point O of q'.

This list is, of course, by no means complete, and might be indefinitely extended.[2]

[2] To obtain the analytical form of theatrical perspective choose again G as the xy-plane, s as the xz-plane, and the plane through C perpendicular to s as the yz-plane. Let b be the distance of C from s, the space in which the object is located as the octant in which all coordinates are positive, e the distance of r from C, e also the distance from s to q', x, y, z the coordinates of a point A, x', y', z' the coordinates of the corresponding point A', then the coordinates are related by

$$x' = \frac{(b+e)x}{y+b+e}, \qquad y' = \frac{ey}{y+b+e}, \qquad z' = \frac{cy+(b+e)z}{y+b+e}.$$

On the stage of a theater the axial plane s may be taken as the plane of the front-curtain, the plane q' as the rear wall of the stage. The observer is supposed to take the place of C. Naturally this theoretically ideal condition cannot be realized practically. There are many observing centers, so that considerable latitude and deviation from the mathematical theory is admissible. Although the mathematician speaks of the plane of the curtain as the invariant plane of the collineation, it is of course not his intention to impose his theory upon the theater-goer.

Fig. 4 represents a typical example of theatrical perspective.

FIG. 4. STAGE-SETTING FOR ACT I. OF PUCCINI'S MANON LESCAUT AT THE METROPOLITAN IN NEW YORK.

It shows the setting of Act I. of the opera "Manon Lescaut" by Puccini at the Metropolitan in New York.

Fig. 5, likewise, may give an idea of the wonderful perspective effect of the stage-setting of the ballroom in the Duke's Palace at a performance of Verdi's Rigoletto, also at the Metropolitan.

The development of the principles of perspective in their practical applications to painting has a long history. It evolved from the primitive, purely intuitional efforts of ancient artists, and reached the present state of a perfect system only after many centuries of improvements and rational scientific coordination with geometry. As a matter of fact, synthetic, or projective geometry grew out of geometrical discoveries revealed by the study of artistic perspective. Desargues's (1593–1662) brilliant accomplishments in this field make him one of the fore-

most pioneers of modern geometry. On the other hand, projective geometry had a great influence upon artistic perspective and the comprehension of its essential simplicity. We have here again a characteristic example for the interesting fact that a branch of mathematical science grew out of a field of practical, more or less intuitional rules, which in its turn was used to clarify the original primitive notions, to simplify and systematize the collection of practical rules and to make their application easier.

Traces of pictorial representation may be found almost as far back as we have knowledge of the prehistoric human race.

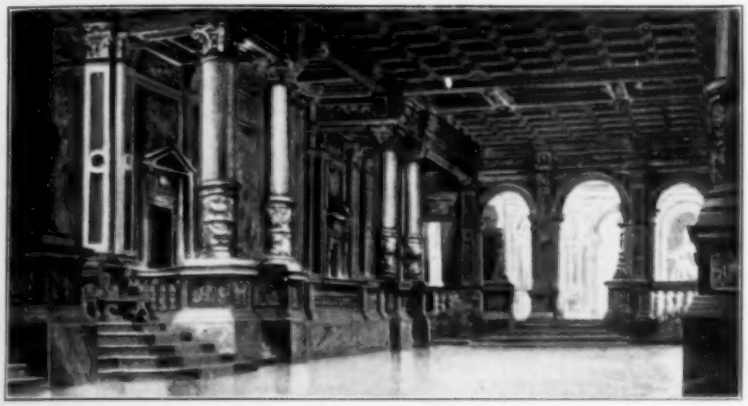


FIG. 5. SETTING OF ACT I. IN VERDI'S RIGOLETTO AT THE METROPOLITAN.

It is, however, not until possibly thousands of centuries later that we see Babylonians, Egyptians, Assyrians and other races make extensive use of graphic representations in their cultural development. But they do not have any knowledge of how to make more than two dimensions appear on a picture. All objects are shown in elevation, or in a front view. When a plan, or top view, is drawn, vertical objects are depicted on the plan as they would appear in elevation.

The ancient Greeks, although even now unsurpassed in sculpture and in the true conception of architectural laws, were not much better when it came to drawing and painting. Front-views were the customary methods of decoration and drawing. As there seem to be no paintings of Greek antiquity in existence, it is impossible to arrive at a correct evaluation of their treatment of form. From writings on objects of art it would appear that the Greeks were not in possession of a deductive system, and that they relied entirely upon empiric, *i. e.*, in this case,

visual impressions. On the other hand it is surprising what anecdotes tell us of some marvelous illusions which Greek paintings seem to have produced. Thus the "grapes of Zeuxis" were painted in such true imitation of nature that the birds tried to pick them. Parrhasius painted an open door with curtain drapery on a wall, through which people, who did not know of the illusion, tried to pass.

As appears from mural decorations of Pompey, Roman artists had some crude knowledge of empirical perspective. But it was without control by correctly deduced geometrical laws, and therefore faulty.

The same may be said of the early Italian painters, like Giotto (1266–1337) and his pupils, whose frescoes in the chapels of St. Croce in Florence, of Madonna dell' Arena in Padua, and others, exhibit very little knowledge of perspective. It was not until the early Renaissance, the Quartocento, that perspective was established as a science. During this period we find writings on the principles of perspective by the architect Brunellesco (1377–1466), by the sculptor Donatello (1386–1468), and by the architect Alberti (1404–1472). The full development and mastery of perspective for artistic purposes was accomplished by the great masters of the Renaissance at the end of the fifteenth and in the sixteenth century: Leonardo da Vinci (1452–1519), Raffael Santi (1483–1520), and Michel Angelo Buonarotti (1475–1564). Leonardo da Vinci, a universal genius, who attained fame not only as a painter, but also in engineering, in physics, in anatomy, and in music, wrote a Trattato della pittura, which contained also a monograph on perspective. Unfortunately this important work has been lost.

As an example of the complete mastery of the laws of perspective I refer to Raffael's "The Wedding of Maria" in the Milan gallery, of which Fig. 6 is a half-tone reproduction. In the whole representation of the architectural features the perspective correspondence between the external world and the canvas is correctly and minutely established. Also the human figures are portrayed with equal carefulness and proper reductions of the scale. In spite of the geometrical correctness of the construction no unpleasing distortions of form appear in the picture. This is the more remarkable as at that time no control by photographic processes was known.

Many other paintings of equal renown by Raffael and other painters of this period might be analyzed, which would merely corroborate the statement concerning the highly and rationally developed sense of form perception of these masters.

FIG. 6. RAFFAEL, THE WEDDING OF MARIA.

It is strange that during the following period some artists became careless in regard to the coordination of their painting with consistent perspective forms. Paolo Veronese's (1528–1588) "The Wedding of Cana," which is in the Louvre (Paris) gallery, for example, contains seven eye-points and five horizons. This is unfortunate, as the painting is otherwise of great artistic value. Fr. Bossuet showed in his "Traité de perspective" (Brussels, 1871), by a reconstruction of the architectural features of Veronese's painting with one eye-point, that the

FIG. 7. ALBRECHT DÜRER, BIRTH OF CHRIST.

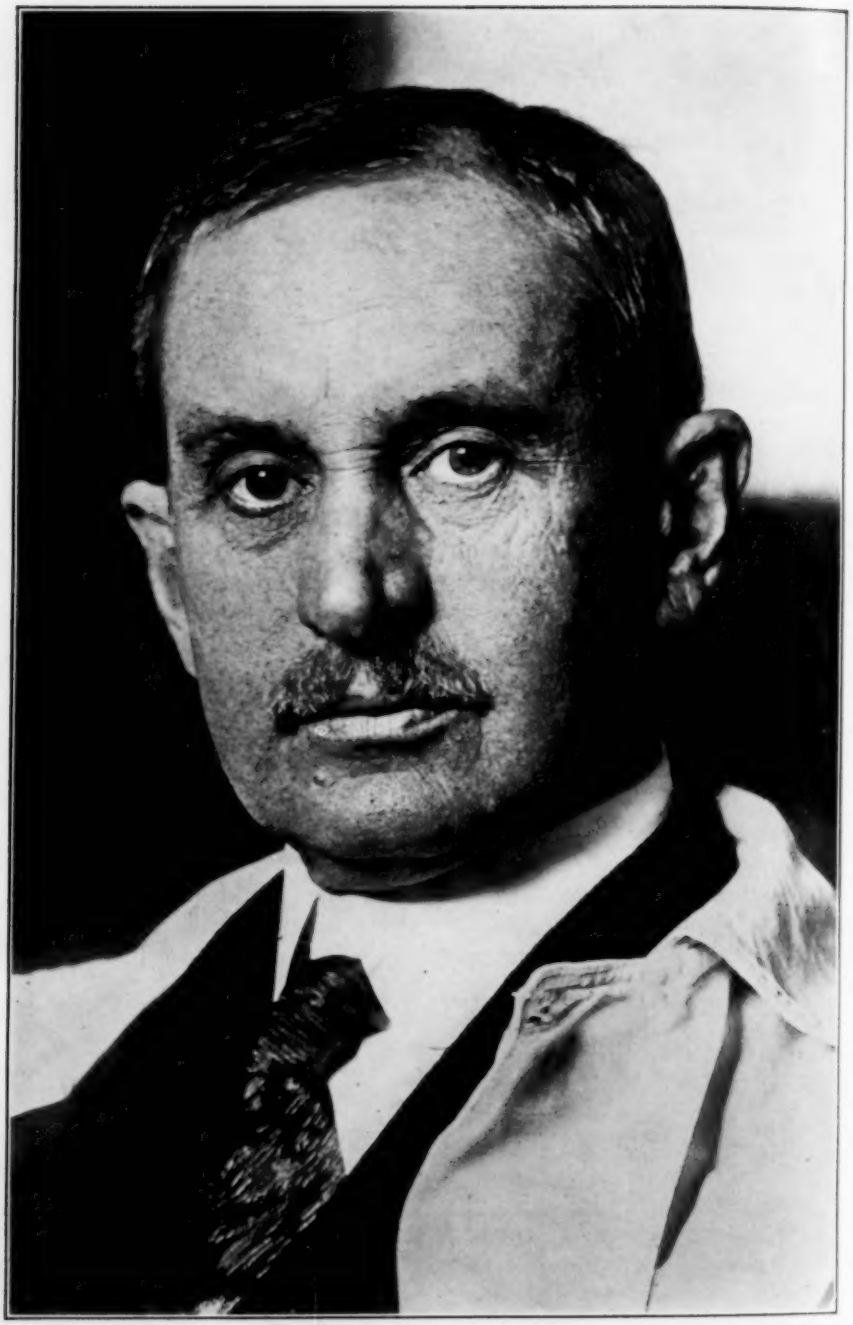
intended impression and effect of the painting do not suffer in the least from a correct construction.

Of other than Italian painters of the Renaissance I shall simply mention Albrecht Dürer (1471–1528), who, like Raffael and his compatriots, had a perfect knowledge of the principles of perspective, as revealed by all his paintings. He wrote the first German work on perspective, called "Unterweysung der

Messung mit Zirkel und Richtscheyt," in which a number of devices (glass plate) are explained how to make true perspective constructions. The "Birth of Christ," reproduced in Fig. 7, is an example of Dürer's art with its careful attention to perspective details.

Most of the great painters of modern times show a profound knowledge of perspective, where proper delineation and reduction of scales are imperative. This, of course, is always the case when architectural features form a part of the setting. See, for example, some of Boecklin's famous paintings, or Rochegrosse's "The Flagellants," in collections of reproductions of modern paintings. Certain styles and varieties of painting require less or no geometrical preliminary work. It must be said, however, that in certain cases deviations from the geometrical laws are permissible. But great painters are conscious of such deviations and do not introduce them deliberately, when not needed. The mistakes of some mediocre painters and their flagrant neglect of correct forms are due not so much to conscious modifications as to their ignorance of the laws of perspective. The mastery of these laws requires some serious thinking and study, which is too arduous a task for so many "heroes of the brush." In so many cases of modernism and impressionism the claim of originality and progressiveness is merely a flimsy cover or excuse for the painter's inability and his ignorance or misunderstanding of some of the most fundamental principles of fine arts.

A thorough mastery of these requires years of intensive study and practise. The lack of these is responsible for much of the mediocrity of the present day.



FRANKLIN PAINE MALL

THE PROGRESS OF SCIENCE

FRANKLIN PAINE MALL

FRANKLIN PAINE MALL, professor of anatomy in the Johns Hopkins Medical School and director of the Department of Embryology of the Carnegie Institution of Washington, was born in Belle Plaine, Iowa, September 28, 1862, and died in Baltimore, November 17, 1917, from complications following an operation for gall stones. He was the son of Francis and Louise (Miller) Mall, both of German descent. In 1895 he married Mabel Stanley Glover, of Washington, D. C. He is survived by his widow and two daughters, Margaret and Mary Louise Mall.

In 1883, he was graduated in medicine from the University of Michigan, and then went to Germany, where he studied first in Heidelberg and later under His and Ludwig in Leipsig. On his return to America he was first fellow in pathology in the Johns Hopkins University, then adjunct professor of anatomy at Clark University, professor of anatomy at the University of Chicago, and finally when the Johns Hopkins Medical School opened he undertook the direction of the new department of anatomy. When he started work, medical education in this country was at a very low ebb. He reorganized the teaching of anatomy by developing a laboratory in which his subject was taught by professional anatomists, devoted to scientific research, and his influence can be seen from the fact that twenty-five of the chairs in anatomy in different medical schools in this country have been filled from his department.

In science he ranks with the great leaders of his generation, and his work, embodied in one hundred and four publications, leads up to certain scientific generalizations. In anatomy he broke away from the study of pure morphology and studied structure from the standpoint of how all of the tissues of an organ are adapted to their function. This work led to the conception that most organs are made up of structural units which are equal in size and in function. The size of these ultimate histological units is determined by the length of the capillary. These ultimate histological units are grouped together into lobules in various ways in the different organs. These conceptions of structure find their best expression in Dr. Mall's studies of the intestine, the stomach, the liver and the spleen.

In the science of embryology Dr. Mall was the first to trace the development of an individual organ from its early embryonic form to its condition in the adult. For example, he followed the development of the loops of the intestine from their beginning, tracing through successive stages their displacement out into the cord, their return to the cœlom, and finally the establishment of their adult position. He determined the normal position of these loops in the adult, and then by experiments on animals showed that when they are displaced they tend to return to this normal position. This type of work may be summed up in the term "organogenesis." Through the complete development of organogenesis the study of anatomy may be rationalized, for thereby normal structure and the limits of variation may be understood.

The later years of his life were devoted to the organization of the Department of Embryology of the Carnegie Institution of Washington.

One of the most striking points in his career is that in these years, devoted to the organization of a new institute, he accomplished some of his best scientific work. He made an exhaustive study of the causes of monsters. To this study he brought a mastery of all the older literature on the subject, a critical judgment in analyzing the results of experimental embryology, and an extensive first-hand knowledge of abnormal embryos. He concluded "that monsters are not due to germinal and hereditary causes, but are produced from normal embryos by influences which are to be sought in their environment." They are due to causes bound up in their faulty implantation whereby alterations in the nutrition of the embryo at an early critical stage produce changes which range all the way from complete degeneration of the embryo up to a monster which survives to term.

In the new institute of embryology Dr. Mall proposed to complete the study of organogenesis and to analyze problems associated with growth which need for their solution large amounts of material and expert technical assistance.

In addition to his great contribution to the development of his science, Dr. Mall was a great teacher. He will be remembered as having trained a large group of the men who are now prominent in scientific medicine. He was one of the foremost men in the reorganization of the American Association of Anatomists, making it one of the distinguished scientific bodies in this country. He played a prominent part in the development of scientific publications in this country, being largely responsible for the establishment of the *American Journal of Anatomy*, the *Anatomical Record*, and finally the *Contributions to Embryology* published by the Carnegie Institution of Washington. He was a man of rare personality; modest, generous, original, unswervingly devoted to ideals and possessed of a genius for stimulating thought.

FLORENCE R. SABIN

A CRYSTAL MIRROR FOR FOCUSING X-RAYS

LIGHT rays may be focused either by passing them through a lens (Fig. 1) or by reflection from a concave mirror (Fig. 2). Although X-rays are known to be of the same nature as light, workers engaged in scientific research have found it impossible to focus them by the first method on account of their stubbornness in resisting refraction, or bending, in passing through ordinary matter, as light rays are bent and focused in passing through a lens. Moreover, difficulty presents itself in attempting to focus them by reflection, for the smoothest mirror that can be manufactured presents a "rough" surface to X-rays, causing them to be reflected diffusely rather than "regularly" (angle of incidence equal to angle of reflection), although presenting a "smooth" surface to light rays, and for the reason that the wave-lengths of X-rays are so very short compared with those of light.

X-rays have nevertheless been recently focused by reflection from a crystal mirror in the new Dershem X-ray concentrator.

It was found only four or five years ago that natural crystal surfaces are "smooth" enough to reflect X-rays regularly rather than diffusely. The idea occurred to Dr. Elmer Dershem, working in the physics laboratory of the University of Iowa, of making a concave mirror of crystal surfaces. Mica is the crystal that comes naturally to mind for such a purpose, as it can be readily split up into thin flexible sheets capable of bending to shape.

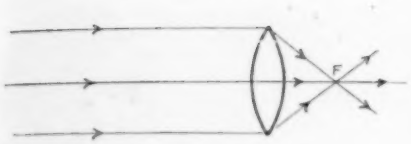


FIG. 1.

FIG. 2.

Fortunately, also, it reflects X-rays exceptionally well.

Dr. Dershem's crystal mirror, while concave, is not made in the usual form of concave mirror, but rather in the shape of an open-ended barrel, such that the source of the X-rays, which is a small spot on the surface of the target in the X-ray tube, is near one end of the "barrel" form were laid the sheets of mica, that were fastened in position by gluing strips of paper over them. The whole was then immersed in melted paraffin, which, on solidifying, gave a cast. The form was then removed, leaving the hollow paraffin cast with the mica held firmly in place against its walls. A horizontal tube lying along the con-

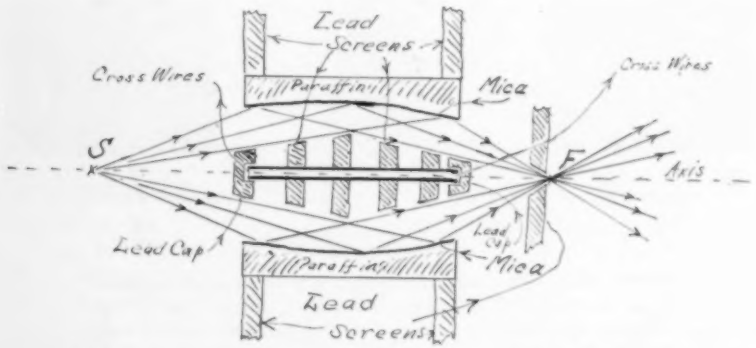


FIG. 3. CROSS-SECTION (SCHEMATIC) OF DERSHEM CONCENTRATOR.

(Fig. 3). The X-rays that would otherwise pass directly through the barrel without reflection from the inside walls are screened off by sheets of lead inserted as shown. The mica barrel is so shaped that an X-ray striking on the inside walls, no matter where, is regularly reflected so that all the reflected rays pass approximately through a point, *F*, the focus.

The first X-ray concentrator was made by turning out on a lathe a wooden form of the desired barrel shape. The diameter of the form was a little over 2 inches, and the length about 4 inches. Over this centrator axis carries a pair of cross wires at either end so that the instrument can be "sighted" on the target of the X-ray tube.

The particular concave shape required for an X-ray focusing mirror was found by mathematical analysis. It is obtained by revolving a segment of logarithmic spiral about an axis formed of the straight line passing through the two points that are to be source and focus, respectively.

The effectiveness of this X-ray focusing mirror, or concentrator, has been demonstrated by photography of the spot focus, with the tungsten target of a Coolidge X-ray tube fur-

DIPHTHERIA TYPHOID FEVER ASIATIC CHOLERA TUBERCULOSIS

MANY diseases are known to be caused by living germs which grow in the body as mold grows in jelly. These harmless-looking germs are so small that millions might lodge on the point of a pin, and yet they cause such diseases as tuberculosis, diphtheria and typhoid fever.

LARVAE AND PUPAE OF THE FILTH FLY IN OLD PAPER

THE HOUSE FLY OR FILTH FLY

MAGGOTS (LARVAE) OF THE FILTH FLY, IN STABLE MANURE

THE House Fly breeds in stables and garbage dumps and might better be called the Filth Fly. From these dirty places it often carries germs on its feet to food that we eat, and thus spreads disease.

A DIRTY COW BARN

MILK from dirty cow barns may carry disease germs. When kept two or three days and handled by several people before reaching the household, it may become so changed as to be poisonous, particularly to babies. Every summer, in New York City, thousands of children die from infected or decayed milk.

THE best way to keep well and to resist disease is to stay out-of-doors during the day in the fresh air and sunshine and to take part in wholesome games. Not only are these conditions conducive to good health, but also they aid the growth and development of the body and keep it strong.

nishing the source. It can also be demonstrated in a qualitative manner with light rays, as was done by Dr. Dershem some months ago at the University of Iowa.

The X-ray concentrator is of particular interest in science because it separates out a single wave-length from a beam containing many wave-lengths, and at the same time focuses it, thus giving a single wave-length with an intensity at least a thousand times greater than can be obtained by the usual reflection from plane crystal surfaces.

There are at least two possible applications that may be made with the X-ray concentrator. One is to study the effect of single wave-lengths of X-rays on the electrical resistance of selenium, since it has been shown that X-rays affect this element in the same way as light waves. The other is to test X-rays of different wave-lengths for their physiological effects, such as X-ray "burns," and the effects of "treatments" by the rays on the human body.

PUBLIC HEALTH CHARTS OF THE AMERICAN MUSEUM OF NATURAL HISTORY

THE Departments of Public Health and Public Education of the American Museum of Natural History five years ago prepared under the direction of Dr. C.-E. A. Winslow, curator of its Department of Public Health, three series of public health charts for the use of schools of New York City. Each consisted of a folio of wall charts illustrated from original photographs and devoted to the following subjects: "The Spread and Prevention of Communicable Disease," "Insects as Carriers of Disease," and "Bacteria and their Work in the World."

The demand for these charts in the schools was many times greater than the supply, and the Museum has now issued a new edition of the set, entitled "The Spread and Prevention of Communicable Disease" in sufficient number to supply all the schools of the city.

There are here reproduced, on a scale comparatively very small, four of the charts. The original charts are 22 x 28 inches each. Each set consists of 15 charts on heavy paper, bound at top and bottom with tin, and suited in every way for hanging on the wall. Although each chart is clearly labeled the sets are accompanied by a booklet containing information which may be of service to teachers in talks on the subject of physical well-being.

The delivery and collection of the charts is being attended to by the museum. As with the circulating collection of natural history specimens, the loan period is three weeks.

The charts may be purchased by educational institutions outside of the city.

MEDICAL RESEARCH IN FRANCE AND THE RED CROSS

THE War Council of the American Red Cross has appropriated $100,000 for general military medical research work in France, including special methods of recognition and study of diseases among soldiers. This action followed a report from the Red Cross Commission in France to national headquarters in which they said:

"An extraordinary opportunity presents itself here for medical research work. We have serving with various American units some of the ablest doctors and surgeons in the United States. Many of these men are already conducting courses of investigation which, if carried to successful conclusions, will result in the discovery of treatments and methods of operation which will be of great use not only in this war, but possibly for years afterwards. To carry on their work they need certain special laboratory equipment, suitable buildings and animals for experimental purposes. At present equipment and personnel can not be obtained through ordinary government sources without delay, which makes this source of supply quite impracticable."

This recommendation, like others of a medical nature from the commission, was submitted to an advisory medical board in France composed of leading American physicians and surgeons working with our forces in that country, and was approved by them.

This advisory board is headed by Dr. Joseph A. Blake, with whom are associated Colonel Ireland, of General Pershing's staff; Dr. Livingston Farrand, president of the University of Colorado; Dr. Alexander Lambert, professor of clinical medicine, Cornell Medical School; Dr. John M. Finney, professor of clinical surgery at the Johns Hopkins University; Drs. Richard P. Strong and W. B. Cannon, professors at Harvard University; Major George W. Crile, head of the Cleveland Base Hospital Unit; and Dr. Hugh H. Young, professor at the Johns Hopkins University.

The committee in charge of this research work in France, headed by Dr. Cannon, includes Dr. Blake, Dr. Crile, Colonel Ireland, Dr. Lambert, Dr. Strong, Dr. Kenneth Taylor, Dr. Harvey Cushing, professor of surgery at Harvard; Dr. James A. Miller, professor of clinical medicine at Columbia; Dr. William Charles White, associate professor of medicine at Pittsburgh; and Dr. Homer F. Swift, professor of medicine at Cornell.

SCIENTIFIC ITEMS

WE record with regret the death of Ellery Williams Davis, dean of the college of arts and sciences and head of the department of mathematics of the University of Nebraska; of Rollin Arthur Harris, mathematician to the U. S. Coast and Geodetic Survey; of Charlotte Fitch Roberts, head of the department of chemistry at Wellesley College; of G. P. Girdwood, professor of chemistry in McGill University, and of C. Christiansen, professor of physics in the University of Copenhagen.

M. PAINLEVÉ, professor of mathematics in the University of Paris and recently premier of France, has been elected president of the Paris Academy of Sciences, succeeding M. d'Arsonval. M. Léon Guignard, professor of botany at the School of Pharmacy of Paris, has been elected vice-president.